SURVIVABILITY SUSTAINABILITY SUPPORTABILITY

TECHNICAL REPORT
NATICK/TR-93/038

AD________________

PLASTICS REMOVAL IN A MARINE ENVIRONMENT (PRIME) - An Overview, October 1988 to September 1992

by

Joseph Wall

September 1993

Final Report

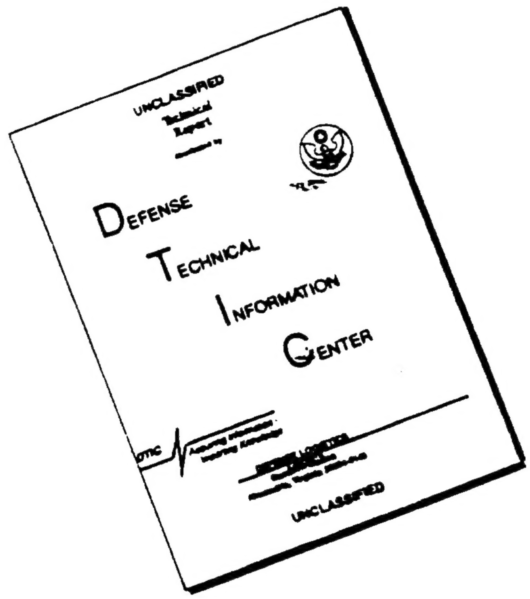
October 1988 - September 1992

Approved for public release, distribution unlimited

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

FOOD ENGINEERING DIRECTORATE

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
September 1993

3. REPORT TYPE AND DATES COVERED
Final Oct 88 - Sept 92

4. TITLE AND SUBTITLE
PLASTICS REMOVAL IN A MARINE ENVIRONMENT (PRIME)
An Overview, October 1988 to September 1992

5. FUNDING NUMBERS
AG Code: 1556
PE: 612786AH 99
PR: 1L12786
TA: 04
WU: 211

6. AUTHOR(S)

Joseph Wall

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Natick Research, Development & Engineering Ctr.
Kansas St., ATTN: SATNC-WE
Natick, MA 01760-5018

8. PERFORMING ORGANIZATION REPORT NUMBER
NATICK/TR-93/038

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Preparation of the report manuscript was in part by GEO-CENTERS, INC., Newton Centre, MA 02159 under Contract No. DAAK60-93-D-0001, Delivery Order No. 0030 and Subcontract GTS-93-01.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Plastic Removal in a Marine Environment (PRIME) is a response by the U.S. Navy to comply with the International Convention for the Prevention of Pollution from Ships and Public Law 100-220, the Marine Plastic Pollution Research and Control Act. The Navy is charged with complete elimination of the discharge of plastics into the oceans and waterways. This project was conducted to explore alternative methods to comply with the prohibition. The project focussed on foodservice operations. Areas examined included biodegradables application, densifying equipment, microbiological considerations, recycling, source reduction, and specifications. The methods of evaluation included shipboard and shoreside personnel surveys. A wide range of groups were involved, including Defense, industry, and academia. The Navy is complying primarily by onboard storage of waste plastic until it can be off-loaded to a shore facility. The shortage of shipboard stowage space is partially alleviated through the reduction of the amount of plastic used. New plastic waste-processing equipment now being developed will further alleviate the problem through a high densification process while reducing sanitation concerns.

14. SUBJECT TERMS

	SHIPBOARD	PLASTICS
OCEAN WASTE DISPOSAL	BIODEGRADABLE PLASTICS	
MARINE ENVIRONMENT	WASTE REMOVAL	NAVY
POLLUTION	MARINE POLLUTION	PLASTIC WASTE PROCESSING

15. NUMBER OF PAGES
126

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified

20. LIMITATION OF ABSTRACT

CONTENTS

CONTENTS *(Continued)*

ALTERNATIVES *(Continued)*

CONTENTS *(Continued)*

LIST OF FIGURES

LIST OF TABLES

PREFACE

This project was originated at the U.S. Army Natick Research, Development and Engineering Center (Natick) by the Advanced Systems Concepts Directorate and completed by the Food Engineering Directorate as part of the Department of Defense Food and Nutrition Research and Engineering Program under U.S. Navy requirement N91-12 from October 1988 to September 1992. Program number and title are 1L162786AH99, Joint Services Food/Nutrition Technology.

The author extends appreciation to his immediate supervisors during the course of the project: Robert Walsh, Harry Kirejczyk, Betty Davis, and Paul Short.

The author also wishes to acknowledge the invaluable advice and assistance provided by Lloyd Cox, Marlene Devine, LT Dennis Grey, Norman Hiatt, Walter Krainski, Francis Lai, Teresa Malafi, Jean Mayer, Joel McCassie, LT John Rogers, Gerald Silverman and Robert Trottier. Special appreciation is extended to Marcia Lightbody for her assistance and skill in report preparation and to Robert O'Brien and Janice Rosado for review of the manuscript.

LIST OF ACRONYMS

A

APA - American Plastics Association
ARO - Army Research Office
ASCD - Advanced Systems Concept Directorate (at Natick)
ASTM - American Society for Testing and Materials

C

CARDEROCKDIV, NSWC - Carderock Division, Naval Surface Warfare Center (formerly David Taylor Research Center)
CID - Commercial Item Description
CINCLANTFLT - Commander-in-Chief, U.S. Atlantic Fleet
CMF - Continuous Melt Filtration
CNO - Chief of Naval Operations
COMNAVAIRPAC - Commander, Naval Air Force, U.S. Pacific Fleet

D

DASO - Defense Analysis and Studies Office
DLA - Defense Logistics Agency
DoD - Department of Defense
DPSC - Defense Personnel Support Center
DTRC - David Taylor Research Center (Now named CARDEROCKDIV, NSWC)

E

EPA - Environmental Protection Agency

F

FDA - U.S. Food and Drug Administration
FF&V - Fresh Fruits and Vegetables
FOD - Foreign Object Damage

G

GSA - General Services Administration

H

HDPE - High Density Polyethylene

I

IMO - International Maritime Organization

J

JTS - Joint Technical Staff - DoD Food Program (U.S.A, U.S.N, U.S.AF, U.S.MC Military representative, plus DLA)

L

LDPE - Low Density Polyethylene

M

MARPOL - Marine Pollution, references the International Convention for the Prevention of Pollution from ships.
MPPRCA - Marine Plastic Pollution Research and Control Act

N

NATICK - U.S. Army Natick Research, Development and Engineering Center (Natick)
NAVFSSO - Navy Food Service Systems Office
NAVRESSO - Navy Resale System Office
NAVSEASYSCOM or NAVSEA - Naval Sea Systems Command
NAVSSES - Naval Ship Systems Engineering Station
NAVSUPSYSCOM or NAVSUP - Naval Supply Systems Command

P

PC - Polycarbonate
PE - Polyethylene
PET - Polyethylene Terephthalate
PP - Polypropylene
PRIME - Plastics Removal in a Marine Environment
PS - Polystyrene
PVC - Polyvinyl Chloride
PWP - Plastic Waste Processor

R

R&DA - Research and Development Associates for Military Food and Packaging, Inc.

S

SSD - Soldier Science Directorate (at Natick)
STSA - Short Term Statistical Analysis

U

UNREP - Underway Replenishment (resupply at sea)
U.S.DA - U.S. Department of Agriculture
U.S.DoC - U.S. Department of Commerce

PLASTICS REMOVAL IN A MARINE ENVIRONMENT (PRIME)

An Overview, October 1988 to September 1992

INTRODUCTION

The plastics industry traces its origins to the year 1868, with the first commercial production of nitrocellulose. Progress in the early years was extremely slow. It took 40 years before the next commercial plastics were introduced. These were condensation products of formaldehyde with phenol, urea and proteins. The slow development was a result of emphasis on chemical composition rather than structure. This emphasis began to change in the early 1900s and the period 1925 to about 1950 saw the introduction of large numbers of synthetic long chain products that achieved commercial success. The availability of large quantities of low cost monomers has resulted in the building of large plants capable of producing polymers for literally pennies per pound. By 1960, the plastics industry was producing 6 billion lb per year. By 1968 production was up to 15 billion lb per year. In the early seventies it topped 20 billion and is presently estimated to exceed 50 billion lb per year.

Concurrently, problems with plastic in the oceans were noted as early as the 1930s, with the discovery of the entanglement of northern fur seals on the Pribilof Islands of Alaska. During the 1960s such incidents were noted with greater frequency. In 1969, U.S. fur seal managers began to monitor the incidence of entangled seals during the commercial seal hunt. Continuing studies indicate that the estimated mortality rate of 50,000 seals per year is contributing to the ongoing decline in the North Pacific fur seal population.

Plastic items discarded in the marine environment are deadly to fish, marine mammals and birds. Deaths are caused through ingestion and entanglement. Plastic in the ocean often appears to be food as it resembles natural food items, such as plankton and fish eggs. Plastic bags can resemble jellyfish when, through the motion of the water, they appear to be alive and swimming. Ingested plastic may lodge in an animal's stomach, blocking the digestive tract. If the stomach has a quantity of plastic, it gives the feeling of being satiated and the creature will not eat and will starve. Entanglement is equally disastrous. Entanglement restricts the motion of fish, animals or birds. They often get hung up on some other object and, unable to get free, they starve or drown. Most visible has been the widely disseminated photo of the six-pack ring around a bird's neck. The ring eventually gets caught on a tree branch or some other object and strangles the bird. These highly publicized tragedies have moved many governments to address the problem.

PROJECT HISTORY

The Marine Plastic Pollution Research and Control Act (MPPRCA), MARPOL and P.L.100-220

The International Maritime Organization (IMO) was established in 1958 as an agency of the United Nations to deal with international shipping issues, which include pollution. Conventions that the UN sponsored eventually led to the adoption, in 1973, of the International Convention for the Prevention of Pollution from Ships (MARPOL, Marine Pollution). The MARPOL protocol of

1978 produced regulations on specific types of pollution. Annexes I-IV of the protocol deal with prevention of pollution from oil, chemicals, hazardous substances and sewage. Annex V deals with garbage, fishing gear, packing materials, dunnage, food waste and specifically prohibits the discharge of all plastics. In December 1987, the U.S. ratified Annex V. Implementing legislation, Public Law 100-220, the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 was signed by the President on December 29, 1987 to take effect on December 31, 1988.

A Role for Natick

In March 1988, the Navy Representative to the Joint Technical Staff (JTS) at the U.S. Army Natick Research, Development and Engineering Center (Natick), advised Natick's Advanced Systems Concepts Directorate (ASCD) of a role for Natick in enabling the Navy to meet the plastic disposal challenge. ASCD agreed to look at the problem and recommend a course of action.

Plastics Steering Group/Plastics Working Group

On the recommendation of Natick, two group, the Plastics Steering Group and Plastics Working Group, were initially established to coordinate and direct the effort. Both groups consisted of representatives of the Chief of Naval Operations (CNO); Commander-in-Chief, U.S. Atlantic Fleet (CINCLANTFLT); Commander, Naval Air Force U.S. Pacific Fleet (COMNAVAIRPAC); Defense Logistics Agency (DLA) and the Defense Personnel Support Center (DPSC); Natick; Naval Supply Systems Command (NAVSUPSYSCOM); Navy Food Service Systems Office (NAVFSSO); and the Navy Resale System Office (NAVRESSO). Although the same organizations were in both groups, their focuses were different. The Plastics Steering Group was to establish policy; the Plastics Working Group was to identify methods and procedures.

Plastics Working Group Meetings - Summary of Significant Points

Minutes of the meetings, without vu-graphs, are available as Appendix A. Since direction for the project resulted from these meetings, a summary of the important items follows. Additionally, an independent evaluation of Natick's proposed recycling alternative was completed, through the Army Research Office (ARO), by Rutgers University. Further discussion of the recycling proposal follows under "Alternatives." The ARO report is included as Appendix B.

It was noted that the project is particularly challenged since industry, almost daily, is developing new uses for plastic. It was suggested that a simple change that would alleviate much of the technical problem associated with processing multiple types of plastic waste is for manufacturers to limit use to two types of plastic: polypropylene (PP) and polyethylene (PE).

Biodegradation of polymers was introduced as a possible alternative. However, it was recognized that biodegradation would not conform to the letter of the law. The MARPOL prohibits ALL plastics. Even though a plastic has the capability to biodegrade, it remains a plastic.

The representative from CINCLANTFLT presented data indicating that, under normal peacetime operations, the typical duration of underway intervals for a ship is less than three days. The fact was also established that three days is the limit on reasonable storage of food-contaminated waste plastic. Under ideal circumstances, ships should be able to store waste plastic for return to shore

facilities, and thus a regulation was enacted requiring all ships to store food-contaminated plastic waste for up to three days. However, as ideal conditions cannot be expected at all times, this regulation is not the total solution. Discussion of highly visible packaging items resulted in an initial list of targeted items for elimination/substitution. That list follows as Figure 1.

ITEM	**RESPONSIBLE ACTIVITY**
Hot drink cup	Natick
Milk bladder	Natick
Absorbent rags	NAVSUP
Frozen meat wrappers	Natick
Plastic trash bags	NAVSUP
Six pack beverage rings	NAVRESSO
Plastic flatware	NAVSUP
Individual portion pack vs bulk	NAVFSSO
List of items available in plastic and nonplastic containers	Natick

Figure 1. List of Target Items for Elimination/Substitution

General comments and points of interest made by the members included:

- It is important to keep the project and its goals visible for support; remain open to all possible alternatives.

- At the present time it appears that industry has no incentives to change from plastic to other materials.

- There have been some adverse effects of advertising degradable products. The public may assume that since the products are degradable it is permissible to litter. It was pointed out that industry uses the term "degradable" very loosely. Manufacturers of wrappings or plastic bags are referring to their products as degradable when, in fact, they are only partially degradable. Small pieces of plastic do remain even after degradation is complete.

- Despite the projected availability of equipment to process plastic waste, it is of major importance to continue a maximum effort to reduce the input.

- Chopping plastic into particles will cause Foreign Object Damage (FOD), the worst case being ingestion into an aircraft engine.

- The weight of the densified product from waste plastic processing equipment must be considered in the design of the equipment.

The American Plastics Association (APA) has developed a symbol/number system to distinguish different plastics (see Figure 2). Compliance is voluntary. Application is becoming widespread. A typical example is a plastic soda bottle. On the bottom is imprinted the triangular arrows symbol and the numeral 1.

The voluntary coding system is not perfect in that, for example, the soda bottle often comes with a cap that is made of some other material. Further, the cap may be lined with yet another material.

SYMBOL (enclosed in ♻)	MATERIAL
1	Polyethylene Terephthalate PET
2	High-density Polyethylene HDPE
3	Polyvinyl Chloride PVC
4	Low-density Polyethylene LDPE
5	Polypropylene PP
6	Polystyrene PS
7	All other resins

Figure 2. Voluntary Plastic Coding Symbols

NAVRESSO sent a letter to 36 suppliers of Ship's Store merchandise requesting that they review their product packaging methods and advise that if plastic were used, could it be replaced or eliminated. Responses are indicated in Table 1.

TABLE 1. Responses of Ship's Store Suppliers on Plastic Use and Replacement

RESPONSE	NO.
Don't plan on changing at this time	3
Partial change/reduced usage	3
Could change/replace, will advise	2
Use discontinued based on NAVRESSO letter	9
Will discontinue by 12/89	3
Do not use plastics	16
	36

The Navy has been primarily using Type Pack 2 packaging. Type Pack 2 packaging includes additional plastic coverings to protect products during adverse weather conditions. DPSC reviewed the Type Pack 2 standardization documents to identify those which permit nonplastic alternative packaging, packing or unitization. DPSC also developed a market survey on those Type Pack 2 items with nonplastic alternative packaging to determine the scope of commercial practice, cost difference and potential procurement problems. During the course of the project, this action led to the elimination of Type Pack 2 packaging.

PROBLEM DEFINITION

With new public recognition and awareness of the negative environmental impacts of conventional landfills, many are closing and few, if any, are opening. The Nation, not just the Navy, is facing

a solid waste disposal crisis. Because plastics are inexpensive they are also disposable, and therein lies the problem. Plastic waste is just one part of the national problem, and since dumping of plastics into the oceans, in particular, has been prohibited, the Navy has been thrust into the leadership role in marine plastic waste disposal.

A universal solution will not be found through the Navy. The Navy is but one small consumer in the overall economy and relies on that economy for its goods and services as well as its work force. Goods are generally wrapped in plastic because of its many advantages. For example, plastic is an excellent material for maintaining medical sterility and food safety; it is also lightweight, unbreakable, microwaveable, conducive to easy product identification, and so on. The Navy work force itself is representative of an increasingly "throwaway" society. If the Navy successfully reduces or eliminates plastic waste, that society will not necessarily change. Nor is the elimination of plastic the best answer in every case. Thus, it was recognized from the outset, that a goal of total elimination of plastic aboard ships was not achievable and that there was no single solution to the problem. A multifaceted solution with contributions from many sources would be required. Given the diversity, size and mission of the array of ships, alternative solutions are applicable in varying degrees, but their impacts must be weighed relative to their contributions to the overall solution.

Historically, Navy ships, like all other ocean-going vessels, have routinely dumped their waste into the oceans. Dumping trash at sea is nothing new. What is new is the composition of the trash. In years past most trash that ended up in the ocean was made of paper or cloth, which decayed in a reasonable period of time. Metal and glass also decay, albeit much more slowly. Today plastic has replaced many of those traditional containers. Plastic decays very slowly. A simple item like a six-pack ring, some estimate, has a life span of 450 years.

The prohibition of dumping plastic into the oceans and waterways creates a challenge that did not previously exist, that is, the need for a practical method to either destroy the plastic on board or find a means to store it until it can be returned to shore. Additionally, much of the plastic waste is contaminated. The contaminated waste referred to in this report is food service plastic packaging that held a liquid, or food that leaves a residue -- typically, meat and dairy products. The problem is twofold: first, finding alternatives to dumping plastics into the oceans and second, addressing the sanitation consideration.

PROJECT OBJECTIVES

To further refine project objectives, Natick representatives made visits to the Navy's David Taylor Research and Development Center (DTRC), Annapolis, MD; NAVSUPSYSCOM, Washington, DC; an aircraft carrier, a frigate and a submarine. Based on information gained during the Navy visits and in discussions with other Natick personnel, it was recommended to representatives of the Chief of Naval Operations (CNO), Naval Supply Systems Command (NAVSUPSYSCOM), Naval Sea Systems Command (NAVSEASYSCOM) and DTRC, in August 1989, that the objectives and course of action of Natick's effort be threefold:

- **To reduce the flow of plastics into the supply system, and subsequently on board ship**
- **To control and manage that which goes on board**
- **To develop a test concept to recycle plastic for storage, off-loading and possible sale.**

For each objective, methods were also to be considered to neutralize the effects associated with contaminated plastic. Later in the project, a decision by the Plastics Steering Group would limit Natick's role to the first two objectives, investigating solutions to source reduction and control and manage; any equipment to be associated with the project would be developed by DTRC. Natick agreed to provide general technical advice to DTRC in solving the problems associated with the application of microbial growth control techniques into whatever system and equipment designs that DTRC would develop. Further discussion in this area is available in the section "Microbiological Considerations."

While the project is funded by the U.S. Department of Defense (DoD) Food and Nutrition Research, Development, Evaluation and Engineering Program (Food Program), the focus is on plastic waste in the food area; it is anticipated that whatever solutions work in the food area will have equally successful application throughout the ship's other departments.

TECHNICAL APPROACH

It was recognized, as the technical approach was being formulated, that a presurvey of shipboard personnel should be designed and distributed. Project personnel felt strongly that problems, and often the best solutions, are identified by the individuals who work with the problem every day. Therefore, the presurvey was completed and distributed in June, 1991; the survey and its summarized results are included herein as Appendix D. Through this survey, Natick hoped to accumulate information so that individual ideas and approaches could be centralized and thus shared. It was also hoped that the survey might identify areas of potential gains that had not yet been evaluated. It was called a presurvey because the intention was to follow up by developing more specific questions. A shoreside personnel survey was also planned to gather further information regarding sailors' awareness and perceptions of the solid waste problem. This survey and its results are discussed in detail in the Alternatives section.

The need was recognized by Natick for much more information on potential markets for recycled plastics. A survey of the recycled plastics aftermarket was developed and is also discussed in the Alternatives section of this report.

Other areas targeted for further study included biodegradables, i.e., the development of packaging materials that naturally break down in a marine environment, over a relatively short period of time, or when exposed to sunlight (photodegradables); microbiological considerations, i.e., how to slow the growth of microorganisms on food wrappings so that the health of sailors and quality of shipboard life are not adversely affected; whether specifications could be changed to eliminate plastic items; and related investigations by other organizations. All of these areas were investigated and are discussed within this report.

Major Areas of Investigation

It was understood that within the Navy, the two organizations that most affected the problem were DTRC and NAVSUPSYSCOM. DTRC is the focal point in the Navy for environmental shipboard systems, while virtually all plastic that finds its way on board ships comes through the supply system.

During the aforementioned visits, information was also collected by Natick for the purpose of understanding existing and planned DoD programs so as to determine a specific role and approach in meeting the recommended objectives.

The first visit was to the Environmental Protection Branch at DTRC (COMM 301-267-3526, DSN 281-3526). Information collected was to make it possible for Natick's ASCD to develop a project that would be cooperative and complementary, as well as original, to the work being done at DTRC and at any other Navy element. Of significance, it was learned that DTRC had been designated as the overall manager of the plastic disposal effort by the CNO (COMM 703-602-2570, DSN 332-2570); it was indicated that their progress was beyond the study stage and efforts were now being implemented, and they had a number of shipboard waste management demonstrations in the planning stages (e.g., recently published, *Navy Solid Waste Management Demonstration Study Aboard U.S.S. Lexington* (AVT-16), CARDEROCKDIV-SME-91/26 October 1992).

Their planned demonstrations focussed on two pieces of equipment under development since about 1980. One was a compactor, which was described as rustproof and "blunderproof." The other was a garbage pulper, which, although not originally designed with plastic in mind, was able to retain plastic while discharging other waste. Additionally, DTRC was already attending meetings of an Ad Hoc Advisory Committee (later called the Keystone Ad Hoc Committee). This committee consisted of Congressional staff members, Navy personnel and representatives of the major environmental groups. In addition to providing expert opinions, the committee provided Congress oversight of the Navy's program to comply with the plastic prohibition. The meetings began in October 1987. Given the depth to which DTRC had already involved itself with plastic disposal technology, it was suggested by DTRC that Natick would likely be more effective working with NAVSUPSYSCOM.

The next visit was to NAVSUPSYSCOM. The sense there was quite different, in that NAVSUPSYSCOM had not been involved in any type of pollution control and recognized they had neither the staff nor the expertise to evaluate the scope of the problem or to determine the best approach to its solution. They welcomed assistance. It was suggested that Natick do an analysis of the problem with focus on the supply system and, in particular, the galley. The galley was recognized as being a major producer of plastic waste due to the number of packages that were disposed of daily.

To get a field perspective, a trip was planned to visit a supply center, an aircraft carrier, a frigate and a submarine. The visits were accomplished in August 1989.

Specific Ships
Aircraft Carrier

An aircraft carrier is often compared to a small city and has all the facilities of a small city, including food service, hospital facilities and industrial areas, the workplace, the recreation area and home quarters, for months at a time, for some 4000-5000 people. As it provides 100% employment, a carrier generates the associated consumer and industrial waste but, until recently, has not recognized the need for a waste management program.

Food Service operates multiple storerooms, galleys and dining areas on several decks, and thus

generates plastic waste at multiple locations. The practice had been to simply place all trash into plastic bags. The bags were discharged overboard through a chute with blades along the side, to make holes in the bags so that they would take in water and sink. As an alternative, a food grinder was available in the dish cleaning room for plate waste.

Frigate

A frigate and similar surface combatants carry a complement of about 300 people. Facilities are extremely limited and space is at a premium. This class does not have the space that is available on an aircraft carrier and, thus, storage of waste plastic is an immense problem. As the food-contaminated waste begins to develop odors, the quality of shipboard life is soon affected. The frigate, likewise, operates several food service facilities and storerooms are remote to the galley.

Submarine

The submarine, due to its even greater compactness, presents a unique environment. Out of necessity, waste management practices have already been adapted to the demands of its situation. All unnecessary wrappers are discarded prior to storage of food on board. Meats and perishables, however, remain in their cartons. Plastic trash bags in various locations seem to be the largest single plastic waste item.

All trash on board is brought to a central location. A perforated metal liner is placed into a compactor and then filled with trash. When filled, it is compressed and weights are added to ensure that it sinks after discharge.

Submarines have traditionally taken as little additional waste on board as possible due to the extreme lack of storage space. Whereas on surface ships pallets are broken down to cases for storage, on a submarine each case itself is opened and the individual can, bottle, bag, etc. is stored. The exterior packaging is left ashore. The only plastic on board is that which cannot be left behind, such as meat and dairy wrappers. Submarines, because they are at sea for long periods and because they do not surface, present a continuing dilemma.

Three-Part Approach

Based on the above experience, inquiries to industry and academia, assessment of current technology and the resources available at Natick, the three-part approach that had been recommended to representatives of the CNO, NAVSUPSYSCOM, NAVSEASYSCOM, and DTRC in August, 1989, was formally recommended to the Navy in September 1989:

- **Reduce the Flow (Source Reduction)**
- **Control and Manage**
- **Recycle**

The project became known as Plastics Removal in a Marine Environment and adopted the acronym PRIME in October 1989.

Reduce the Flow (Source Reduction)

Simply stated, the problem could be solved by eliminating disposable plastic on board; however, it was recognized that complete elimination of all plastic is not realistic and that the trend is, in fact, toward increased use of plastics. At least in some cases, however, plastic packaging can be eliminated or significantly reduced. To this end, the aforementioned Plastics Working Group, which consisted of representatives from the operational and support activities that have knowledge of the systems and could influence change, met to address specific items and potential solutions. "Reduce the Flow" came to be called "Source Reduction" and this is now the common term in federal and local solid waste disposal terminology.

Control and Manage

The plastic that comes on board must be controlled so that it is not inadvertently disposed of overboard. Critical control points were recommended where plastic waste could be collected, with the galley being a primary point. Additionally, the sanitation problems associated with the storage of food-contaminated plastic waste were identified. The main problem identified was that microbial activity, if left unchecked, soon results in pronounced, objectionable odors.

Recycle

Recycling of the waste plastic was viewed as the most important of the three recommended efforts. If the ships could be provided with an on board, sanitary and relatively easy to operate device to recycle plastic into a readily stored commodity, its handling could be as routine as handling food waste. Although source reduction efforts should continue, a recycling device would reduce the pressure, if not eliminate reliance on source reduction solutions. Further, the control and manage function can focus on ensuring the waste plastic gets into the recycling device where waste control is further guaranteed -- in essence, provide the sailor with a tool to do the job.

The initial recycling recommendation in this area was to recycle on board, on the premise that the closer to the problem that the solution can be applied, the more effective will be the result. As the size of the ship decreases, this approach becomes less applicable and less efficient. The mission of the ships, the relative space, and the typical number of days deployed must be considered. With the cost, limited space and the lower volume of waste plastic, it becomes obvious that recycling equipment cannot, and should not, be on every ship.

For those ships that would not be equipped with a recycling device, it was envisioned that they would off-load waste plastic to larger ships (resupply ships), which would be equipped with a recycling device. On short deployments the waste plastic would be returned to a shore facility.

ALTERNATIVES

Within the three-part approved approach -- to reduce the flow of plastic on board ship, manage and control that which must go on board, and recycle -- a number of alternatives were considered. There is something of a hierarchy among the three efforts, with some type of recycling considered the most important. The rationale here is that if the sailor is provided a tool that allows safe and easy processing of the plastic waste, the necessity for the other two measures is much diminished.

Further, the easier it is to comply, the more likely the sailor will do so. To reduce the flow through source reduction is always a positive policy as it simply makes good sense to eliminate waste before it becomes waste. The control and manage aspect is the important intermediate step to ensure the plastic does not end up overboard and to deal with the sanitation problems associated with food-contaminated plastic waste.

Source Reduction

Source reduction is generally accepted to be the reduction of toxicity and volume of materials used in packaging that are destined to become part of the waste stream. Source reduction is the prevention of waste before it becomes waste. Reuse or reclaiming disposable materials contributes to source reduction by lowering demand for virgin resins. If a package can be reused, it lowers demand for additional packaging, thereby reducing the waste stream.

Substitution, when possible, is the easiest method of source reduction and has been employed where possible. Next, larger packages are used, where appropriate, instead of numerous smaller ones. Last is conservation, i.e., reusing where possible and using less. Figure 3, which follows, summarizes the major actions in shipboard source reduction.

PROGRESS

Wax paper substitute for plastic wrap
Bulk vs individual condiments
Wet strength paper bags vs plastic
Paper towels vs plastic reinforced towels
Styrofoam eliminated
Packing materials changed/reused
Shrink-wrap used less
Coffee stirrers, nonplastic
Container reuse
Order nonplastic products where there is a choice
Leave plastic on shore
Elimination of six-pack rings, plastic gloves and aprons
All-paper hot cups

NO PROGRESS

Dairy products
Meat wraps
Vegetables wraps
Plastic flatware

Figure 3. Source Reduction Initiatives

As a method of source reduction, ethylene absorber blankets (potassium permanganate and aluminum oxide) have been adopted for use by the Navy to extend the shelf life of fresh fruits and vegetables. Some types of fresh fruits and vegetables (FF&V) naturally produce a ripening agent, ethylene gas. The ethylene absorber blankets (NSN 6850-01-303-1336) remove that gas, thereby retarding spoilage. With ethylene absorber blankets, plastic wrap on FF&V is not required. At this point the blankets are expensive -- $108.79 per 10 lb blanket -- but do provide an alternative solution. The blankets are hung in walk-in refrigerators, preferably in close proximity to recirculating fans so that air will pass through the blanket. The circulating air is scrubbed of ethylene gas, retarding the maturation process. The amount of blanket required is approximately equal to (lb FF&V) x (no. days chill space available) x (0.0001).

A replacement for the general use plastic lined paper cup has been sought from the beginning of the project. The high cost for new development of an all-paper cup had been an economic barrier; however, one company was able to adapt an existing technology, at a fairly low cost, to produce such a cup. In July 1992, a 100% paper cup was tested at the Newport, RI Naval Base. Technical Report CID A-A-2577 (Cup, Disposable: Lid, Disposable Cup) is being revised. The cup has been assigned NSN 7350-01-359-9524 and is now available through General Services Administration (GSA).

Source reduction for the Navy includes the above, but is unique in that it is a combined effort involving the supply centers as well as the ships.

Role of the Naval Supply Center

The various supply centers provide the ships with virtually all the food materials they need to perform their missions. Some exceptions are perishable items, such as bread and milk, which are delivered directly to the ship (local purchase). Typically, materials are ordered from the vendor and delivered to the supply center for subsequent distribution to the various ships. In many cases the entire pallet is simply shipped as received.

Quantities less than a pallet load are repacked by supply center personnel and either placed in a triwall container (pallet base with fiberboard walls and a cap), or shrink-wrapped by hand. The shrink-wrap performs very well in securing loads with uneven, odd shapes, e.g., different size product containers.Triwalls are an alternative to shrink wrap. However, triwalls are labor intensive and significantly expensive, estimated at $12.00 -- vs $0.60 for shrink wrap.

At a nonperishable food warehouse, it was observed that 99% of what is received from manufacturers comes with shrink-wrap on the pallet. This makes shrink-wrap a highly visible item. Shrink-wrap is favored because it facilitates easy handling by preventing cases from falling off the pallet. This is most important to load stabilization during shipment by truck from the warehouse to the ship. When the pallets arrive at the surface combatants, the shrink-wrap, for the most part, is removed and disposed of in shore facilities. As pallets do not fit through the typically sized hatch, each case is manually carried to its respective storeroom.

There was some belief that the shrink-wrap helped prevent insect infestation, but the on-site veterinarian inspector disagreed. He indicated that strapping was the preferred method, from an inspection point of view, to unitize a pallet.

Metal strapping, in lieu of shrink wrap, has been abandoned because it is difficult to work with and because of the potential damage if inadvertently ingested in a jet engine.

The supply center cannot be faulted for producing plastic waste. It serves as the middleman between the manufacturer and the user. Commercial practices prevail.

Control and Manage
Biodegradables

Of potential alternatives, the availability of materials that could biodegrade in a marine environment promise to have wide application within and outside the Navy. Thus, in FY90

PRIME brought in the Soldier Science Directorate (SSD) at Natick to develop polymers for packaging applications that are water soluble and ultimately biodegradable, to include polymers that are inherently biodegradable or that photodegrade. Because of the great potential in this area, the investigation of biodegradables was separated from PRIME in FY91 to become an independent project. This subject has expanded in focus and includes now biodegradable materials based on thermoplastic starch technology and the development of methods to expedite the commercialization of the technology. The objective remains that of providing alternatives to plastic for shipboard use. In this effort, Natick is working with the U.S. Department of Agriculture, Warner-Lambert Company, the Massachusetts Institute of Technology (MIT) and the University of Hawaii.

Because the practice had been to dispose of all trash overboard, a major change was required in the process. This change required the separation and retention of all plastic from the established waste stream. In the case of food, the galley was identified as a collection point. Training was required and was implemented on-the-job and through a number of videos. Identified as a particular problem was the food-contaminated waste plastic.

Microbiological Considerations

Some plastic wrappings, especially for food, become coated with residue -- blood, fats, oils, food particles, etc. The growth rate of microorganisms, and their production of highly unpleasant volatiles on food waste, can be significantly slowed or prevented by, for example, adjustments in temperature and pH, the removal of oxygen, incineration, the presence of solutes in high concentration, dehydration, improving sanitation, the use of plastic overwrap and the addition of germicides. The selective use of these techniques can also alter the type of volatiles produced so that the aroma is tolerable. The methods identified for the control of microorganisms are physical and chemical.

The physical methods are incineration and dehydration. Incineration will sterilize the plastic or if sterilization is not achieved, the dry residue will prevent microbial growth, provided it is maintained dry. Dehydration does not have to sterilize the plastic but can be effective by preventing microbial growth. Thermal dehydration in an oven removes all water so microorganisms are unable to grow. If high enough temperatures are used then almost all, if not all, of the microorganisms present can be destroyed. The material must then be stored in a dry, protected area. Desiccants can also be used to absorb liquids. Inert desiccant mixed with the plastic essentially removes all free water, thereby preventing microbial growth. The desiccant material must be available in sufficient quantity for the absorption of water and must be in contact with all of the water. It should be minimally corrosive. Chemical sterilants of interest are acids, gases, halides, alcohol, quaternary ammonium compounds and peroxides. It is not necessary to sterilize the plastic as growth inhibition will be sufficient. An anticipated problem is that during extended storage these chemicals may lose some of their effectiveness, resulting in the initiation of bacterial growth.

In order, the simplest technique is incineration, followed by dehydration, with the most complex being the use of chemicals. All of these techniques have microbiological problems, especially as to the evaluation of their effectiveness.

Role of Specifications

Specifications are developed by the government to describe specifically what it is that the government desires to procure. Specifications provide the manufacturer with specific guidelines to meet the government standards. A section of the specification document identifies the types of packaging that are acceptable. In recent years there has been a trend toward less dependence on specifications and more reliance on Commercial Item Descriptions (CIDs). In the food area specifications are prepared by Natick, U.S. Department of Agriculture (USDA) and the Department of Commerce (DoC).

A review of specifications was conducted to determine if specifications could be changed to eliminate plastic. Of 100 military/federal specifications prepared by Natick, with operational rations excluded, 63 were not a problem in that they are packaged in fiberboard, glass or metal cans. Thirty-seven had nonplastic or plastic packaging alternatives, e.g., pasta products -- paperboard box or poly bag. Of 60 CIDs, 30 had nonplastic or plastic packaging alternatives. Of 18 specifications prepared by the USDA and the DoC cited in DoD procurement, three had plastic packaging alternatives. Of 33 CIDs, 10 had plastic packaging alternatives.

These data were made available to the Navy for information and guidance. Specifications are subject to periodic review. A continuing aspect of that review will be the plastic content of packaging with a view to reducing and eliminating.

Recycle

Recycling is the reprocessing of materials that have fulfilled their original purpose so that they become reusable. The recycling process has many facets but it is important to remember that recycling does not occur until the loop is closed, i.e., the materials are, in fact, reused.

There are four types of plastic recycling. Each is addressed separately as follows:

1. *Primary recycling:* wastes that have not been contaminated with other wastes. This is typically preconsumer waste.

2. *Secondary recycling:* waste plastic that has been made into another product and may have inferior qualities.

3. *Tertiary recycling:* waste plastic utilized to produce basic chemicals and fuels through processes such as pyrolysis and hydrolysis.

4. *Quaternary recycling:* retrieves the plastic's heat content by burning, which is generally referred to as incineration.

Primary Recycling

When asked, most companies that produce plastic products will respond that they do recycle. The response can be misleading unless it is clear that it applies to both pre- and postproduction waste. What they most often refer to is primary recycling. Primary recycling is the use of plastic that becomes waste through the production process and is reentered into the system. It never leaves

the factory and the assurance of its quality is not questionable. Typically, the recycled material is the trimmed material necessary to clear rough edges of a finished product or the excess produced as the plastic exceeds the confines of the mold. Primary recycling is not relevant on Navy ships.

Secondary Recycling

Secondary recycling is concerned with consumer waste. The plastic waste is collected, reduced to its resin form and then used again, generally with additional virgin resin, to make a new product. The most successful commercial and municipal collections have been with PET and HDPE. The PET is the primary material for the manufacture of soft drink bottles, while the HDPE is used in milk containers. Both are used in great quantities and are easily recognizable. Soda bottles or milk bottles are not typically used aboard ship. Secondary recycling was considered as an option on-board ship; however, it has not been pursued due to space, labor, energy required and the lack of a single target resin such as PET or HDPE.

Tertiary Recycling

The easiest method for a sailor to deal with the plastic waste problem would be to have a device available into which he could simply deposit it. Pyrolysis is a recycling process for a wide variety of materials and especially for plastics waste of different origins, as is typical on Navy ships.

Pyrolysis means thermal splitting of organic molecules in the absence of oxygen. Pyrolysis destroys the waste at high temperatures, producing a gas and leaving a biologically inert residue, both of which can be used as fuel sources.

Hydrolysis, a chemical process of decomposition involving splitting of the polymer bond and the addition of elements of water, is another option.

Quaternary Recycling

Quaternary recycling is basically incineration. According to estimates, only 25% of all the plastic waste projected to be produced during the coming decade has the realistic potential to be diverted from disposal because of technical and institutional problems. The opportunities for recovering the 75% balance of the plastic waste stream appear to be limited to tertiary and quaternary processes.

In contributing to this project, Dr. Francis Lai, Plastics Engineering Department, University of Lowell, who is in favor of pyrolysis, provided an evaluation of the possible use of pyrolysis on-board ship, compared with incineration. His conclusion is that pyrolysis has advantages over incineration including:

- Pyrolysis disposes of many hazardous wastes, in addition to plastic; pyrolysis is suitable for paper, wood, rubber, textiles, food waste and sewer sludge
- Pyrolysis onverts waste to energy

- Environmental safety favors pyrolysis
- Pyrolysis plants require a smaller capital investment than other methods
- Pyrolysis plants have lower operating costs than other methods
- Large air transport systems are not required
- Air pollution devices may not be required.

Preliminary tests conducted at the University of Lowell show the system concept has great promise. The system's potential benefits, including compactness, reduced maintenance, and its waste-to-energy feature make it a candidate for consideration in the future construction of ships. Dr. Lai's work is contained in Appendix C, *A Discussion of Pyrolysis of Plastic Waste.*

The Navy has not indicated a high degree of interest in incineration because of safety and environmental concerns. A major concern with traditional incineration is the disposal of the ash. If the ash is clean, it could be disposed of overboard; however, if the incineration device does not operate efficiently and combustion is incomplete there could be pieces of plastic remaining.

Of interest, but not of particular application to shipboard problems, is the fact that the U.S. supply of oil is expected to be exhausted about the year 2000. The energy produced from combustion of one ton of mixed trash is equivalent to 1.5 barrels of oil.

Naval Ship Supply Engineering Station (NAVSSES) has conducted some shipboard incineration tests and these continue. The U.S. Coast Guard is currently involved in developing standards for materials to be used in shipboard incinerators. Based on the PRIME investigation, it is concluded that recent advances in combustion technology now permit most hazardous and nonhazardous wastes to be safely incinerated. This includes all plastic materials currently found in both packaging and nonpackaging applications, albeit, when necessary, with the addition of pollution control devices. In particular, the modular controlled-air incineration would be the system of choice. Modular controlled-air incinerators are manufactured by a number of companies and are currently available in a wide capacity range. This permits maximum flexibility and latitude with regard to the selection of incinerator size and duty cycle for a variety of sizes of ships. Future developments in the field will undoubtedly affect future decisions on the use of thermal destruction methodology.

Although the idea of recycling, per se, was rejected, a follow on, related, recommendation was accepted, i.e., simply densify the plastic by fusing. The current adaptation, instead of "melting" the plastic and then extruding it, is to compress, fuse by heat and shape the outer layers only. The waste plastic between the fused outer surfaces would be compacted and held immobile. This device, now called the Plastic Waste Processor (PWP) is under development at DTRC and is projected to be on ships beginning in FY96. The adaptation and adoption of the concept is considered a major accomplishment of this project. The benefits of this approach over recycling are that it is less costly, reduces sanitation concerns by the application of heat and, also, reduces the need for plastic substitutes, thereby avoiding cost increases.

The concept is based on technology as exists in a device called the ET-1, available from Advanced Recycling Technology of Belgium. Following the insertion of chopped waste plastic, this device thermally "melts" and extrudes comingled plastic into shapes determined by molds. The most common sizes currently in use are 2" x 4" x 8' and 2" x 6" x 8', commercially merchandised as plastic lumber. The concept addressed downsizing the ET-1 to produce a product about the size of a brick, i.e., 2" x 4" x 8". The heating process retards bacterial growth and the brick size would be conducive to easy handling and storage. It is understood that the purer the plastic recovered, the greater its value. Notwithstanding, it was recommended that the plastics on ships be comingled to avoid the time, labor and type identification required in separating the waste plastic.

Surveys

Recycled Plastics Aftermarket Survey

With the collection of waste plastic came the question of what to do with it. One of the possibilities the Navy considered most desirable was to sell it and raise money for sailors' recreational needs. To determine the potential, a survey of the market for used plastic materials was completed in January 1990 by Dr. Norman A. Hiatt. It had been determined that the Navy would not separate waste plastic due to the training, labor, space equipment and expense involved. The single most important factor affecting the value of waste plastic is its purity. To achieve this required level of purity, the waste plastic must be separated and be clean, i.e., free of labels and residual contaminants. The survey confirmed that the comingled waste plastic coming from the ships has little commercial value.

The aftermarket for waste plastic is faced with problems in collection and in separation. The lack of mechanical means makes both processes labor intensive. At present most of the development in plastic reclamation has been directed to PET and HDPE. These materials are used in bottles and in large volume. Further, some states have bottle bills requiring a deposit and thus encouraging their return to collection points. Other plastics being recycled include LDPE, PP, PS, PVC, and polycarbonate (PC). Plastics that are difficult or cannot be recycled include saran and thermoset plastics such as epoxies, melamine, crosslinked polyesters and acrylics.

Another factor affecting the value is the availability and price of virgin plastic. Prices for selected recycled plastic and virgin plastic for July 1991 and May 1992 appear in Table 2.

TABLE 2.
Prices Per Pound, for Virgin and Recycled Plastic, July 1991 - May 1992

Type of Plastic	Virgin 1991	Virgin 1992	Recycled 1991	Recycled 1992
High Density Polyethylene	$ 0.43-0.46	$ 0.33-0.35	$ 0.21-0.23	$ 0.28-0.32
Polyester bottles				
clear	0.65-0.67	0.62-0.64	0.40-0.42	0.43-0.54
green	0.65-0.67	0.62-0.64	0.30-0.32	0.34-0.40
Polypropylene	0.41-0.43	0.42-0.43	0.12-0.16	0.24-0.27
Polystyrene	0.45-0.47	0.47-0.49	0.19-0.23	0.33-0.35

The price for HDPE was, in 1992, at the lowest in a decade. Oversupply has been the response to a previous shortage, thus changing a price-driven market into a demand-driven market. In some areas, suppliers pay to have mixed bags taken away.

At first glance it would seem that, according to price, there should be a great demand for the recycled plastic. There are several reasons why there is not. If the plastic has been colored it cannot be made a lighter color the second time around. It cannot be used as primary packaging for food products because its purity cannot be guaranteed. Its quality as compared to virgin cannot be guaranteed. Decline in quality is directly related to the number of times it has been heated.

The plastic waste aboard ship is of the comingled variety. Most of the recyclers in the U.S. are not equipped to recycle comingled plastic, although some are. The most common product produced with comingled plastic is plastic lumber. In an effort to increase use of comingled plastic waste, the Army Corps of Engineers, Rutgers University and the Port Authorities of New York and New Jersey are currently involved in a research program to set standards and develop new applications for the use of plastic lumber. Plastic lumber currently sells for about three times the price of wood. As new applications are developed, it is expected that the market will broaden and be profitable. Plastic lumber is particularly adaptable for use in the marine environment, as it does not rot.

The potential for products made with recycled plastic is only beginning. Figure 4 shows end products from recycled plastics. Note that the uses for comingled plastics are few.

<u>**Polyethylene Terephthalate**</u>

fibers	strapping	fiberfill for pillows
carpet face yarns	scouring pads	ski jackets,
twine	fence posts	sleeping bags
filter material	parking space bumpers	cushions
apparel	rope	paint brushes
industrial paints	textiles	belts
webbing	woven bags	Polyol, a chemical used by urethane foam manufacturers

<u>**Engineering Plastics**</u> - alloyed or modified PET to produce appliance handles, automotive components, and tire cord

<u>**Unsaturated Polyester**</u> - a chemical component used to produce:

bath tubs, sinks, swimming pools, boat hulls, shower stalls, corrugated awnings, six-pack carriers, automobile exterior panels, nonfood containers, audiocassette cases, thermoformable sheets

(continued)

Figure 4. End Products from Recycled Plastics

High Density Polyethylene

lumber
fencing
landscaping timbers
pig and calf pens
vine and tree stakes
outdoor furniture
litter receptacles and signs
milk bottle crates
flower pots
trash cans
signs
toys
kitchen drain boards
pails and drums
playground structures
traffic barrier cones
base cups for soft drink bottles
golf bag liners
drainage pipes
soft drink bottle cases
speed control bumps
parking stops

Low Density Polyethylene

Film stock in combination with some virgin LDPE which can then be used to make pallet wrap and bags.

Composites

Polyvinyl Chloride

drainage and irrigation pipe
thermal sheet
pipe fittings
curtain rods
vinyl floor tile
garden hose core
insect traps
vacuum cleaner piping
fencing
handrails
truck bed liners
cushioned laboratory mats
golf club tubes
bird feeders
general purpose containers
drain spouts

Polystyrene

pen holders, foam insulation, memo pads, video cassettes

Comingled Plastic

landscape ties
industrial molding
plastic lumber

Figure 4. End Products from Recycled Plastic *(Continued)*

Shipboard Personnel Survey on PRIME

A survey, addressed to the Executive Officer or the PRIME POC, was sent to randomly selected ships, two per class of ship, during the month of August 1991. Fifteen responses were received (38%) and these are summarized in Table 3. The purpose of the survey was to identify waste

management issues and/or areas not yet evaluated, the extent to which the PRIME program was known and implemented, and to accumulate additional ideas and approaches so they could be shared. A copy of the cover letter, survey, and summary of responses appear as Appendix D. At the time the survey was being sent, the effort to expand the development of biodegradables for packaging was getting underway. Two additional questions were included to develop an initial measurement of the awareness and understanding of the need for plastics removal and recognition of biodegradable concepts. Survey results are presented in Table 3.

Table 3
Respondents' Points of Concern on Plastic Removal Survey

Item	Times mentioned
Training	18
Storage space	17
Styrofoam	13
Trash compactor	11
Milk container	10
Source reduction	9
Plastic wrap	9
Food service	9
Technology/equipment	8
Plastic bags	8
Bubble wrap	8
Outside support	5
Command support	5
Garbage grinder	5
Ship's store	4
Detergent containers	3
Labor/manning	2

The single area mentioned most often was training. However, if the compactor and garbage grinder were grouped with the more generic "technology/equipment," the total of that group would be 24 and that would be the highest ranking and, presumably, the area of greatest concern.

Excluding question 17, which addressed training specifically, the need for continuous training in waste management was mentioned 18 times. On one response, training materials and a visit were requested. Educational videos on the marine pollution problem and the Navy's responsibility were noted as being very useful; however, one respondent stated having a movie would be beneficial, indicating no knowledge of the videos available. Given the turnover of personnel, need for a system that applies only at sea, and a tendency to revert to old ways, an ongoing program to upgrade and maintain PRIME awareness appears essential to success.

Storage space was the next concern most mentioned. It was mentioned in the context of little space available but, also, for not having a specific waste area designated and specific containers to accommodate the storage and off-loading of waste plastic.

Styrofoam "peanuts" and "popcorn" used as packing materials were the most frequently mentioned types of problematic plastic (13 times), followed by the milk bladder (10), plastic wrap (9), plastic bags (8), bubble wrap (8) and detergent containers (3).

The most often mentioned piece of equipment that would aid in the storage of plastic was a compactor (11). Mentioned five times was the garbage grinder in the context that if the grinder was always working properly there would be a significant decrease in wet garbage and in plastic bags used to carry the wet garbage. Technology/equipment was mentioned eight times in reference to new devices that would make the tasks simpler and easier.

Outside support and Command support were both mentioned five times each. The outside support referred to suppliers, contracting officers, supply system and shippers contributing positively to the reduction of plastic going on board. Command support was mentioned as being significant in compliance with the established procedures for collecting, separating and ultimately keeping the plastic waste from going overboard.

Source reduction was mentioned nine times with recognition that if it doesn't come on board it doesn't have to be handled.

Food service was mentioned nine times as a major source of plastic waste and in particular contaminated plastic waste. The ship's store was mentioned four times with regard to snack items wrapped in plastic.

Additional labor and lack of increased manning to implement the program was mentioned twice.

Shoreside Personnel Survey

As part of the Soldier Science Directorate (SSD) project underway at Natick for the development of biodegradable materials that will be used to meet PRIME objectives, the project team visited Newport, RI during July, 1991, and conducted a survey to aid in the development of educational, promotional, and motivational strategies to be used when biodegradable products become available for shipboard use. Twenty-seven enlisted personnel were interviewed.

The results, as pertinent to PRIME, follow:

A. Awareness of Environmental Problem at Sea

- Sailors are aware of the problem and think it is important for Navy to be involved
- Most sailors learned about the problem outside the Navy.

B. Knowledge/Perceived Impact of Biodegradables

- Most sailors had heard the term "biodegradable" and could correctly define it.
- Most sailors had no clear idea about the impact of biodegradables on the quality of food packaging, their workload, or on the environment.

C. Waste Disposal Procedures

- All sailors separate their trash in multiple cans; separation is a shared responsibility.
- Plastic waste is stored onboard until in port; storage is perceived as a health/safety problem.
- Most sailors learned about trash procedures in their current position, but received no "standard" training.
- Most sailors feel more training is needed on the effects of dumping plastic and why separation of trash is necessary.

A second and larger survey was conducted on ships at San Diego and Pearl Harbor. A total of 369 sailors provided the following results.

A. Sailors are concerned about plastic pollution.

- The majority think that finding solutions should be a priority.
- Using biodegradable materials was rated by most sailors as the best way to deal with the problem.

B. Sailors want more information.

- 35% reported receiving no training about plastic waste disposal.
- 60% want more training that focusses on information rather than just rules.

C. Sailors know what "biodegradability" is but are unclear about the effect of using biodegradable materials.

- 87% identified a simple definition of "biodegradability".

D. Several types of communication strategies are seen as effective.

- Strategies mentioned as being effective were direct orders from superiors, Plan-of-the-day, Quarters, presentations by other sailors, and videotapes.

Equipment Development for PRIME

During the third year of the PRIME project, the Navy representative to the Joint Technical Staff (JTS) requested that the project be extended to maintain Natick expertise through the 1 January 1994 compliance date.

Natick's 6.2 portion of the PRIME project focussed upon nonequipment alternatives to dumping plastic waste in the oceans. Equipment development is the responsibility of CARDEROCKDIV, NSWC, Annapolis, MD 20084-5000 and includes compactors, pulpers and Plastic Waste Processors (PWPs).

The PWP, based on a Natick concept, is a device under development that will compress waste plastic. Heat applied to the outer surfaces fuses those surfaces while contributing to bacteria growth control and odor suppression. The PWP produces a flattened square shaped disc. The

interior waste plastic is held immobile. PWPs are expected to be available in FY96. Other equipment alternatives will be installed over a period of years and will not be available for every ship. Thus, a niche for an immediately available interim technology exists. In 6.3A, Natick sought that alternative approach. The objective was to demonstrate a device that would chop and wash waste plastic, particularly the food-contaminated waste plastic produced by the food service operations aboard ship. The chopping, by eliminating form, shape and, thereby, airspace, would permit densification of the waste plastic so that it would be easier to manipulate and carry, and would occupy less storage space. The washing, by eliminating or diluting food residue, would neutralize the associated odors, provide better sanitary conditions and the ability to store the food-contaminated waste plastic for longer periods of time. The alternative decided upon is the shred-rinse system.

The shred-rinse system is an off-the-shelf, commercially available system. It shreds the waste plastic and then rinses it. This process will allow the storage of food-contaminated waste plastic in less space over longer periods of time. Should the waste plastic processed through the shred-rinse system continue to give off unpleasant odors, it can be repeatedly reprocessed through the shred-rinse system, thereby extending the potential storage period indefinitely. The use of salt water in the rinse process can aid the sanitizing effects.

The system consists of a shredder into which the waste plastic is placed. After shredding it is carried upward via an auger in a trommel. As it travels, the waste plastic is sprayed with water. The rinse water travels down the trommel to a holding tank where it is pumped to a drainage receptacle. The waste plastic travels up the trommel to an opening at the top where it falls into the storage container. Use of the system shows that without further manual or mechanical compaction, a reduction ratio of 3 to 1 is achieved.A videotape, unedited, documenting the features of the system and demonstrating its operation has been distributed to Navy decision makers.

RELATED INVESTIGATIONS BY OTHER ORGANIZATIONS

Defense Analysis and Studies Office (DASO)

The Secretary of Defense was tasked via the National Defense Authorization Act for fiscal year 1989 to determine the feasibility of substituting degradable for nondegradable plastic for items used by the DoD. DASO was assigned to do the study and visited Natick in June 1989 to collect PRIME data. Their report was published in March 1990 and concluded:

> Considering the lack of definitions, standards, etc., and the state of current technology, we do not consider conversion to degradable plastic items feasible at this time. However, our proposed actions in this area are:
>
> - Support actions of the U.S. Environmental Protection Agency (EPA), the U.S. Food and Drug Administration (FDA), and industry to definitize degradability concepts, establish standards and develop testing methods.
>
> - Intensify management attention to ensure disposable plastic items inventory levels are kept to minimum required.

- Fund government and industry research efforts through joint action programs, contract incentives, etc.

- Enhance awareness and sensitivity of degradable programs.

American Society for Testing Materials (ASTM) -- Definitions and Standardization of Testing

In recent years, commercial products have been marketed as being degradable. These products did have some degradable components but in general such claims can be considered to be misleading. A typical degradable component has been starch. The product may consist of as much as 20% starch. True, the 20% starch will degrade but the 80% plastic remains, albeit in another shape. There is concern that this labeling has caused skepticism on the part of the public and may cause difficulties in introducing truly degradable products.

The ASTM is a national, nonprofit organization that writes standards for materials, products systems and services based on the consensus of producers, users and consumers. Questions raised concerning the technical basis for marketing "environmentally safe" products using claims of bio- or photodegradability have moved the ASTM Committee on Plastics to form a subcommittee (D20.96) to standardize degradability definitions and testing methodologies. Natick participates in the committee, particularly in the areas of standards for biodegradation testing in marine and soil environments.

Of particular significance to PRIME is the wording of the MARPOL treaty prohibition on dumping of all plastics into the oceans and waterways. Interpretation of the definition of plastic in the treaty by some agencies includes degradable plastics as a subset of plastics even though most of them are not synthetic high polymers. Many degradables are made from naturally occurring materials. The Coast Guard has been charged with enforcement of Public Law 100-220, MPPRCA. They have developed a definition of plastic that reads:

> Plastic means any garbage that is solid material, that contains an essential ingredient of one or more synthetic organic high polymers, and that is shaped either during the manufacture of the polymer or polymers or during fabrication into a finished product by heat or pressure or both.

The definition allows disposal of polymers that are naturally produced in the marine environment, but excludes packaging materials derived by man. PRIME suggests instead of debating the issues of plastic vs. nonplastic or natural vs. synthetic, the issue should revolve around the environmental fate of any material that is released into the environment. If it can be shown by standard toxicity tests and standard marine biodegradation tests (which ASTM is developing) that a material degrades, by any mechanism, into nontoxic components in the marine environment, then disposal should be permitted. This view has been presented to the Keystone Ad Hoc Committee.

Research and Development Associates (R&DA) for Military Food and Packaging, Inc.

The R&DA was formed in 1946 as a nonprofit association to coordinate research and development activities in the areas of food, food packaging, food service and equipment between the Armed Forces and the Federal Government on the one hand, and industry and university professors of food science on the other. This group, which meets each year in the spring and fall, was addressed in an attempt to raise industry awareness and to seek help in the area of source reduction.

Membership in the industrial category is restricted to companies, large or small, engaged in:

- Production, processing, preparation, packaging, storage or distribution of food and food products

- Design, manufacture or distribution of containers and packaging materials

- Manufacture of food processing, food service and packaging equipment

- Manufacture of chemicals, flavorings and pharmaceutical products.

Food packaging is recognized as the number one producer of waste plastic aboard ship. The industrial companies that belong to R&DA are the companies that produce the packaging and package the products. The R&DA provides a unique forum to speak directly to those companies that make the decisions on what kinds and how much packaging to use that ultimately ends up on ships. The R&DA was approached with the goals of educating organizations on the nature and extent of the waste disposal problem as it affects the Navy and to influence their packaging decisions to favor the Navy.

At the outset of the PRIME project the R&DA was addressed by Natick in general session and as a result a Special Working Group was established to investigate specifically the plastic and solid waste disposal problems facing the military. The work group outlined its purpose, mission and objectives as follows:

1. *Purpose:* To maintain objectives and goals consistent with the spirit and intent of Research & Development Associates for Military Food & Packaging Systems, Inc.

2. *Mission:* To coordinate the requirements to assist the military in complying with newly imposed restrictions on disposing of waste at sea and jointly resolve future restrictions of solid waste and plastic waste in landfills.

3. *Objectives:*

   a. Organize a legal forum for a team effort to implement solid waste and plastic disposal programs coordinating armed forces and industry objectives which meet both federal and municipal regulations that are environmentally acceptable.

b. Develop a plan for both armed forces and industry to reduce solid waste volume through source reduction and recycling specific solid waste components.

c. Develop a plan for both armed forces and industry to landfill solid waste remaining after recycling, in compliance with local and federal standards.

d. Recommend actions to both armed forces and industry to implement commercially viable strategies to manage solid waste and its disposal.

e. Support national education programs encouraging solid waste recycling in cooperation with industry organizations.

Coordination and cooperation between Natick and R&DA in this matter continue. Understanding of the problem and participation by industry in the solutions are essential to long-term success.

CONCLUSIONS AND RECOMMENDATIONS

Tremendous progress has been made in technical and educational areas for the prevention of plastic waste pollution by the Navy during the course of this project. Only under the most extreme conditions is any plastic dumped. New tools, such as a second generation Plastic Waste Processor (PWP), should be sought to aid sailors, particularly in the area of food-contaminated waste plastic. The benefits of this approach over recycling are that it is less costly, reduces sanitation concerns by the application of heat and also reduces the need for plastic substitutes thereby avoiding cost increases.

The Navy is a leader in the prevention and elimination of marine pollution, and its methods will undoubtedly be imitated. Much of what has been implemented and planned will have civilian application.

As indicated at the outset of this report, the Navy's problem with plastic reflects that of the economy that supports it. All nonoperational food products purchased by the Navy are packaged according to standard commercial practices. In most cases this includes plastic. As a result, the complete elimination of plastic aboard ship is not feasible, nor is it necessarily desirable: plastic remains the best material for maintaining medical sterility and food safety, both of which are of paramount importance. Plastic presently is also the best material to provide the product shelf life required by the Navy.

Notwithstanding, source reduction of plastic waste has an important place as a continuing effort within the Navy to reduce the volume of the plastic that must be dealt with. The greatest potential in source reduction, given the actions already taken, is reduced packaging. To purchase products with reduced packaging will encourage further reductions and influence manufacturers' future selection of materials and package design.

Plastic waste treatment centers should be considered in all new ship construction. Complementary facilities should also be available on shore.

Advantages provided by biodegradable products should be seized when available. Biodegradable materials have tremendous potential, both within and outside the Navy. Efforts of SSD to develop water-soluble, biodegradable or photodegradable polymers resulted in an independent project, separated from PRIME in 1991, with an expanded focus. Included now are biodegradable materials based on thermoplastic starch technology and the development of methods to expedite the commercialization of the technology. The objective remains to provide alternatives to plastic for shipboard use.

The collection of comingled plastic should continue, as available alternatives are too labor-intensive and cumbersome. Plastic lumber, the most common product made from comingled plastic, is particularly well-suited for the marine environment as it does not rot. The Army Corps of Engineers, Rutgers University and the Port Authority of New York and New Jersey are currently involved in a research program to set standards and develop new applications for the use of plastic lumber. As new applications are developed, it is expected that the market will broaden and be profitable.

Training in plastic waste disposal is required at all levels to further increase awareness. Training should be ongoing due to the unique requirements of shipboard life and the frequent change from shore to ship living. Training was mentioned more than any other area on the shipboard personnel survey. Training materials and educational videos on the marine pollution problem and the Navy's responsibility were noted as being very useful; however, their use needs to be more consistent. An ongoing program to upgrade and maintain PRIME awareness appears essential to success.

ADDENDUM

1993

During the third year of the PRIME project, the Navy representative to Natick's Joint Technical Staff (JTS) requested that the project be extended to sustain Natick expertise through the 1 January 1994 compliance date. Natick agreed; however, as there were no funds available in 6.2 - exploratory development, the project was funded in 6.3A - technical demonstration.

The 6.2 portion of the PRIME project addressed nonequipment alternatives to dumping plastic waste in the oceans. Equipment development for PRIME is being conducted by the Carderock Division of the Naval Surface Warfare Center, Bethesda, MD 20084-5000 and includes compactors, pulpers, and Plastic Waste Processors (PWPs).

The PWP, based on a Natick concept, is a device under development that will compress waste plastic. Heat applied to the outer surfaces fuses those surfaces while contributing to bacteria growth control and odor suppression. The PWP produces a flattened square- shape disc. The interior waste plastic is held immobile. PWPs are expected to be available in FY96. Other equipment alternatives will be installed over a period of years and will not be available for every ship. Thus, a niche for an immediately available interim technology exists.

In 6.3A, Natick sought that alternative approach. The objective was to demonstrate a device that would chop and wash waste plastic, particularly the food-contaminated waste plastic produced by the food service operations aboard ship. The chopping, by eliminating form, shape, and, thereby, airspace, would permit densification of the waste plastic so that it would be easier to manipulate and carry and would occupy less storage space. The washing, by eliminating or diluting food residue, would neutralize the associated odors providing better sanitary conditions and the ability to store the food-contaminated waste plastic for longer periods of time. The alternative decided upon is the Shred-Rinse system.

The Shred-Rinse system is an off-the-shelf, commercially available system. It shreds the waste plastic and then rinses it. This process will allow the storage of food-contaminated waste plastic in less space over longer periods of time. Should the waste plastic processed through the Shred-Rinse system continue to give off unpleasant odors, it can be repeatedly reprocessed through the Shred-Rinse system, thereby extending the potential storage period indefinitely. The use of salt water in the rinse process can aid the sanitizing effects.

The system consists of a shredder into which the waste plastic is placed. After shredding, it is carried upward via an auger in a trommel. As it travels, the waste plastic is sprayed with water. The rinse water travels down the trommel to a holding tank where it is pumped to a drainage receptacle. The waste plastic travels up the trommel to an opening at the top where it falls into the storage container. Use of the system shows that without further manual or mechanical compaction, a reduction ratio of 3 to 1 is achieved.

A videotape, unedited, documenting the features of the system and demonstrating its operation, has been distributed to Navy decision makers.

This document reports research undertaken at the U.S. Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-93/038 in the series of reports approved for publication.

APPENDIX A

Plastic Steering Group Minutes, 1989

&

Plastic Working Group Minutes, 1989

DEPARTMENT OF THE ARMY
U.S. ARMY TROOP SUPPORT COMMAND
NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MA
01760-5015

REPLY TO ATTENTION OF

STRNC-AA

8 February 1989

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Minutes of the Plastics Steering Group/Plastics Working Group Meeting on 4 January 1989

1. Enclosed for your review and comments are the minutes of the subject meeting held at this Center.

2. To provide comments or additions to the minutes, contact the U.S. Army Natick RD&E Center project officer, Joseph M. Wall, Autovon 256-4508.

FOR THE COMMANDER:

Peter Bolan

Encl

PETER BOLAN
Acting Director, Advanced Systems
Concepts Directorate

DISTRIBUTION

CNO, (OP-452)
COM, NAVFSSO
CINCLANFLT (Code N421)
COMNAVAIRPAC (Code 452A2)
NAVSUP (Code 5522/Code 032)
COM, DTSRDC (Code 2834)
Cdr, DLA (DLA-DOSO-DOI)
COM, FOSSAC (Code 06)
COM, NAVRESSO (Code SSD2)
COM, NAVSEASYSCMD (Code 56YP)
COM, ONT (ONT-226)
Cdr, DPSC (DPSC-HS)
GSA, (J. Miller)
University of Lowell (Prof. Lai)

MINUTES OF MEETING

FOR

PRIME
Plastics Removal in a Marine Environment

4 JANUARY 1989
PART ONE

1. Reference message 211535Z, subject, Plastic Removal in a Marine Environment (PRIME) Work Group Meeting.

2. The meeting was hosted by the USA Natick RD&E Center, Natick, MA. on 4 Jan 89. The purpose of the meeting was two fold; to bring together those working on the plastics removal problem for a mutual sharing and report on individual efforts and; to determine members of the Plastics Working Group and conduct the first meeting.

3. DISCUSSION:

a. USN REPRESENTATIVE TO THE JOINT TECHNICAL STAFF. Lt. Dennis Grey referenced the 10 Aug 88 meeting which discussed USA Natick RD&E Center's proposal for participation in the PRIME program. Natick's thrust would be to find alternatives to plastic packaging (food), support in how to handle/store waste, provide technical support in identifying alternatives to current packaging problems and recycling. Lt Grey went on to explain to the participants how this meeting would be structured. The meeting would be divided into two parts; a Steering Group where participants would explain what their agencies' mission is and how it relates to PRIME; and, a Plastics Working Group (PWG) who (after determining membership), would attempt to prioritize and solve/improve specific problems in packaging that currently contributes to the PRIME problem. It is a priority to speed compliance within the 5 year time constraint.

b. USA NATICK RD&E CENTER PRIME PROJECT OFFICER. Mr. Joseph Wall delivered a presentation on on the background of the problem and Natick's involvement from March 88 until now. Copies of the vu-graphs used are attached.
To deal with all aspects of the problem the Center has put together a team that in addition to Mr. Wall includes:

CONCERN		OFFICE SYMBOL
Mr. Stephen Rei	Data Base Manager	ASCD/CSSD
Ms. Betty Davis	Specifications	EPMD/ESS
Mr. Joel McCassie	Packaging	FED/WTS
Dr. Gerald Silverman	Contaminated waste	SATD/BIOSCI
Ms. Jean Mayer	Biodegradables	SATD/MPED

Mr. Wall introduced Dr. Francis Lai, the IPA assignee from the University of Lowell. Dr. Lai presented slides on his 2 year program for development of a prototype shipboard recycling system for plastic wastes. Dr. Lai explained his main tasks would be to: 1. collect data; 2. collect typical plastic waste; 3. construct a prototype recycling system which is the core of his tasking; 4.test run the system; 5. modify the system, and 6. implement it.

Several points of discussion arose from Dr. Lai's presentation:

Q: Can we develop a land system? and would it be better?
A: Yes, less odor, no space, size or weight constraints and more opportune locations.

Q: Is this way economically profitable enough to stand alone?
A: Yes, could work in our favor.
A: Mr. Wall explained that this has not been the objective up to now but could be.

Mr. Wall then introduced Dr. Gerald Silverman of the Science and Advanced Technology Directorate (SATD). Dr. Silverman explained his role in the project which is the concern with the handling, storage and processing of contaminated plastic waste.

Dr. David Kaplan and Ms. Jean Mayer, also of SATD, were introduced and explained their area of concern with biodegradable plastics. Biodegradation raised several questions:

Q: Is there a residue after biodegradation?
A: Yes, but certain polymers can completely biodegrade.

Q: Although you can biodegrade on land, can it/will it be environmentally safe in the marine environment?
A: There are different approaches to solving the problem and this aspect will be addressed.

General comments made at the time indicate that biodegradability does not meet the letter of the law and therefore the answer lies in the prevention of dumping of all plastics at sea. Other comments were as follows:

o Don't want to duplicate what industry is doing; have quarterly meeting for updates on everyone's progress

o Biodegration is a hot subject and its investigation should be pursued

o Lt Grey reminded that the current plan makes use of the s we have to work to solve the problem within the 5 years as opposed to working on things that would be long range (10-15 years)

o Need to find a product that biodegrades before ingestion, entanglement, etc.

o Need to define specifically what plastic is.

o If it costs too much to recycle, take it to a land fill.

o It was suggested to melt and fuse waste so it's easy, convenient and sanitary to bring back to shore.

o Fiberboard is also a large problem

At this point Lt. Grey invited participants to comment on what they are doing relative to PRIME.

c. CINCLANTFLT. Commander Chitty gave a presentation on activity in LANTFLT which included, fleet criteria, results from the demonstration ships, data on frequency of underway intervals, tons of plastics discharged, test ships, fleet policy, and reporting requirements.

d. DAVID TAYLOR SHIP RESEARCH AND DEVELOPMENT CENTER. Mr. Craig Alig discussed progress to date on their work the compactor, pulper and on degradable plastics.

e. DEFENSE LOGISTICS AGENCY. Mr. Thomas Mc Elovee commented that this was their first involvement with PRIME and would participate as required. He mentioned that he was a fill-in at this time and, likely, the person to be involved is Becky Barker.

f. DEFENSE PERSONNEL SUPPORT CENTER. LTC James Elmore commented that DPSC responds to the services requirements and orders what they want. Some discussion was held on specifications, the process of changing them and on commercial item descriptions (CID's).

g. NAVY FOOD SERVICE SYSTEMS OFFICE. Commander John Hartman explained that his office provides technical direction, policy and procedural guidance to Navy messes. The main thrust in the PRIME program is to oversee what Natick is doing and represent the Navy's interest through the DoD Food Program.

h. FOSSAC. Commander Peter Watson represents the Director, Logistics Engineering and acts as an Engineering consultant to NAVSUP primarily in the area of storage design. He indicated he had no clear PRIME mission at this time but would respond as required.

i. COMNAVAIRPAC. Mr. Jerry Parks provides liaison for testing. He's attending to become familiar with where the program is up to now. He will be available to coordinate any efforts in the Pacific Fleet.

j. NAVRESSO. Mr. John Dixon will coordinate through NAVSUP and will provide updates on the Resale System efforts to reduce plastics. Some items of significance include the elimination of plastic carry out bags and progress on eliminating the six pack ring and the plastic overwrap on soda cases.

k. NAVSUP. Mr. Ken Thompson is the NAVSUP POC for the PRIME program and coordinates the NAVSUP effort. He emphasized the need to reduce the volume of plastic and the importance of documenting the reduction as a means of indicating to the Congress and others that progress is being made. Some of the activities he is involved in include; alternatives to shrink wrap, opening contacts with GSA, replacement products such as paper cups for styrofoam, wooden for plastic stirrers, spork (combination of spoon and fork) to reduce volume of plastic flat ware and the like. Also in attendance from NAVSUP, from the Research and Development and Finance areas were Ms. Sandra Borden and LCDR Andy Baivier.

l. SUMMARY. After an open discussion the following were agreed to.

(1). Support to DTSRDC. It was agreed in principle that Natick, Dr. Silverman, would provide support to DTSRDC in the area of microbiology, specifically, contaminated plastics. This is subject to the spelling out of specifics and providing additional funding. This is in addition to the support that Dr. Silverman is providing to the Natick PRIME program.

(2). Support to DTSRDC. It was agreed in principle that Natick, Dr. Kaplin, would provide support to DTSRDC in the area of nonplastic food packaging. This is subject to the spelling out of specifics and providing additional funding. This is in

addition to the support Dr. Kaplin is providing to the Natick PRIME program.

(3). Fresh Fruits and Vegetable Wrappings (FFV). The R&D on the FFV wrappings has shown positive results and should be integrated into the system as rapidly as possible.

(4). Support to the Natick RD&E Center. The estimates for funding of the PRIME project for FY 89 amount to 395K. Present funding is 222K. It was agreed that the Navy would provide the additional 173K. (Specific distribution of funds is outlined in the Technical Plan).

(5). Prototype Recycling System. It was agreed that the recycling program proceed with a change in emphasis/direction. The recycling system should focus on shore operation rather than onboard ship. Mr. Wall pointed out that these are two separate sets of criteria and the shore based is the less demanding since the constraints associated with the shipboard (weight, size, power, water, etc.) operation are removed and it shouldn't be expected that they be interchangeable. Dr. Lai concurred.

(6). Tech Advisory on Hit List. It was agreed that with the resident expertise in packaging and specification writing that Natick will coordinate a supply oriented effort to eliminate/substitute for plastic where possible. This will include the continuing development of a data base. All concurred with the establishment of a plastics working group for this purpose.

PART TWO

a. With the business of the Steering Committee completed focus turned to the Plastics Working Group (PWG). Lt Grey and Mr. Wall presented a conceptual outline of the intended operation of the PWG; copy of vu-graphs are attached. Based on the focus of the PWG the participants were offered the opportunity to choose to become part of the PWG. Criterion was the ability to contribute.

At this time, those who did not choose to become members adjourned from the meeting. Just prior it was agreed that the Plastics Steering Group (consisting of all attendees) would meet quarterly in conjunction with the PWG on PRIME that would also meet quarterly. The Natick DR&E Center will be the primary meeting location, however, it may be at other locations should there be a benefit derived. The next meeting will be in April 1989.

b. Members of the PWG are as follows:

NATICK RD&E CENTER		
Mr. Joseph Wall	PRIME Project Officer	AV 256-4508
Mr. Steve Rei	Data Base Manager	-5063
Mr. Joel McCassie	Packaging	-4062
Dr. Gerald Silverman	Contaminated Waste	-4900
MS. Betty Davis	Specifications	-5907
NAVSUP		
Mr. Ken Thompson.	PRIME POC	AV 225-6096

NAVFSSO		
Cdr John Hartman/	XO	AV 288-3075
Lt Dennis Grey	JTS REP	AV 256-4509
NAVRESSO		
Mr. John Dixon	PRIME POC	AV 456-2712
CINCLANTFLT		
Cdr Fred Chitty	PRIME POC	AV 564-6852
COMNAVAIRPAC		
Mr. Jerry Parks	PRIME POC	AV 735-1034
DLA		
Ms Becky Barker	PRIME POC	AV 284-6266
DPSC		
LTC James Elmore	PRIME POC	AV 444-2951

c. After discussion on organization and procedures the PWG established an initial list of target items. The list and the responsible activity is as follows:

ITEM	Activity
Hot drink cup	NATICK
Milk bladder	NATICK
Absorbant rags	NAVSUP
Frozen meat wrappers	NATICK
Plastic trash bags	NAVSUP
Six pack beverage rings	NAVRESSO
Plastic flatware	NAVSUP
Individual portion pack vs bulk	NAVFSSO
List of items available in plastic and non-plastic containers.	NATICK

d. In concluding remarks it was suggested that in the future the two meetings continue to be in tandem, however, one afternoon and another the following morning would be better than all in one day. With a reminder that the next meeting would be in April the meeting was adjourned.

NAVFSSO		
Cdr John Hartman/	XO	AV 288-3075
Lt Dennis Grey	JTS REP	AV 256-4509
NAVRESSO		
Mr. John Dixon	PRIME POC	AV 456-2712
CINCLANTFLT		
Cdr Fred Chitty	PRIME POC	AV 564-6852
COMNAVAIRPAC		
Mr. Jerry Parks	PRIME POC	AV 735-1034
DLA		
Ms Becky Barker	PRIME POC	AV 284-6266
DPSC		
LTC James Elmore	PRIME POC	AV 444-2951

c. After discussion on organization and procedures the PWG established an initial list of target items. The list and the responsible activity is as follows:

ITEM	Activity
Hot drink cup	NATICK
Milk bladder	NATICK
Absorbant rags	NAVSUP
Frozen meat wrappers	NATICK
Plastic trash bags	NAVSUP
Six pack beverage rings	NAVRESSO
Plastic flatware	NAVSUP
Individual portion pack vs bulk	NAVFSSO
List of items available in plastic and non-plastic containers.	NATICK

d. In concluding remarks it was suggested that in the future the two meetings continue to be in tandem, however, one afternoon and another the following morning would be better than all in one day. With a reminder that the next meeting would be in April the meeting was adjourned.

DEPARTMENT OF THE ARMY

U.S. ARMY TROOP SUPPORT COMMAND
NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MA
01760-5015

REPLY TO ATTENTION OF

STRNC-AA

17 July 1989

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Minutes of the Plastics Steering Group/Plastics Working Group Meeting on 3-4 May 1989

1. Enclosed for your review and comments are the minutes of the subject meeting held at this Center.

2. To provide comments or additions to the minutes, contact the U.S. Army Natick RD&E Center project officer, Joseph M. Wall, Autovon 256-4508.

FOR THE COMMANDER:

Encl

PETER BOLAN
Acting Director, Advanced Systems Concepts Directorate

DISTRIBUTION:

CNO, (OP-452)
COM, NAVFSSO
CINCLANFLT (Code N421)
COMNAVAIRPAC (Code 452A2)
NAVSUP (Code 5522/Code 032)
COM, DTSRDC (Code 2834)
COM, DLA (DLA-DOSO-DOI)
COM, FOSSAC (Code 06)
COM, NAVRESSO (Code SSD2)
COM, NAVSEASYSCMD (Code 56YP)
COM, ONT (ONT-226)
Cdr, DPSC (DPSC-HS)
GSA, (J. Miller)
University of Lowell (Prof. Lai)

Minutes of the
Plastic Steering Group

3 May 1989

1. On 8 March 1989, the Advanced Systems Concepts Directorate, with prior coordination issued a memorandum announcing the scheduled meeting to be held at the Natick RD&E Center at 1300 hrs on 3 May 89.

2. Those in attendance were as follows:

Natick RD&E Center

LTJG John Rogers, USN JTS Rep.
Joseph Wall, Natick Project Officer
Stephen Rei, Data Base Manager
Joel McCassie, Packaging
Victor Latchica, Microbiology
Betty Davis, Specification
Jean Mayer, Biodegradables
Heidi Stacer, Biodegradables
Francis Lai, IPA assignee, University of Lowell

NAVSUP

Kenneth Thompson, NAVSUP Project Officer

NAVFSSO

LTJG John Rogers

DPSC

LTC James Elmore

DLA

Becky Barker

GSA

Thomas Rogers

3. Discussion:

a. LT Rogers opened the meeting with welcoming remarks. He explained that the meeting would be in two parts as was the original meeting, the Steering Group and the Working Group. Due to the absence of key Navy figures, Larry Koss, CNO, and Crag Alig, DTSRDC, a follow on meeting has been scheduled for Friday, 26 May 89 in Washington D.C. to discuss changes in the recycling portion of the program. All other efforts of the program remain on track. The results of the meeting on the 26th will be attached to the minutes for everyone's information.

b. Joseph Wall spoke briefly on the Steering Group organization and then presented an update on the Natick effort.

He commented that the Steering Group is a participatory group with the singular purpose of bringing together those working on the plastics removal problem for mutual sharing of information and an update on individual activity. The objective is to conduct a coordinated, effective program.

Individual presentations will be made as appropriate and there will be a round table discussion allowing everyone the opportunity to provide input. The information may be a lead for someone and, at least can reduce duplication. It is extremely useful to writing the minutes if this information can be put on paper for simple insertion.

In practically every endeavor we are going against the trend. Industry is developing new uses for plastic and increasing its use. Plastic is replacing other materials while we are trying to replace plastic. We must continue to realize that we cannot replace plastic in every instance. When breakthroughs occur it is important to get the word out quickly. Don't wait for the next meeting.

Agenda items were requested when the meeting was announced. None were received. You are all encouraged to get on the agenda to keep the meetings purposeful.

As to the Natick update, Mr. Wall began by reviewing the Natick requirement which is, to eliminate all dumping of plastic from ships. The planned actions to accomplish this goal were stated as:

- reduce the flow of plastics onto the ships,
- control and manage that which does go onboard, and
- recycle

The most important of these is the recycling because when the ships have a method to take care of the plastic it reduces the importance and immediacy of the others.

He went on to present a chronology of events dealing with the recycling portion of the project.

- September 1988	Navy accepted the Natick proposal for shipboard recycling.
- January 1989	Navy directed change from onboard to land.
- February 1989	A new proposal for land based recycling was forwarded and included a request for a meeting to discuss it prior to the next Steering Group meeting.
- March 1989	A meeting was held in March and the result was to take no action on a complete recycling system but to focus on one aspect of the system which is unique, the "continuous melt filtration (CMF) .

At this point Mr. Wall introduced Dr. Francis Lai of the University of Lowell who is on assignment with Natick to work the recycling concept. In the ensuing discussion the following points were made:

- The land based recycling system can be assembled from components available in the marketplace. The CMF is unique to the system proposed because, as far as is known, this component is not in recycling operations in this country. Its purpose is to filter out impurities in the plastic melt thereby leaving a pure resin. The purer the resin in a recycled plastic the greater its value. The CMF is used primarily as a quality control device manufacturing situation to filter out any impurities that might have accidently mixed with the virgin resin. Natick's challenge would be to take the concept and develop it for use with commingled waste plastics.

- The CMF does not stand alone. It requires a forward device to create the plastic melt and an aft device to receive the filtered melt and do something with it; in essence a mini-recycling system.

- If manufactureres could be convinced to use two types of plastic Polypropylene (PE) and Polyethylene (PET) the recycling process and the resulting pure product would be greatly aided.

- The word 'recycling' must be understood in the context used. What recycling means to us is not the concept prevalent in industry. In industry recycling means reusing the excess that is formed in using a mold. The end product usually is trimmed and these trimmings are 'recycled'.

- Mr. Wall does not recommend that Natick pursue the CMF as in and of itself CMF does not contribute to eliminating the dumping of plastics.

Mr. Wall then suggested that we return to some of the original and basic concepts, to wit, densify by fusing into a brick or to chop it into particles. It is understood that some work has already been done at DTSRDC on the brick concept. There is technology available to densify and chop but it would have to be modified/adapted for ship use. The advantages of these options were listed as less costly, would significantly reduce sanitation concerns, and reduce the need for plastic substitutes. It is recognized that this may create a problem for the shore base and, if so, should it be looked at separately.

Moving on, Mr. Wall listed some of the other activity during the quarter:

- The Short Term Analytical Services (STAS) conducted through the Army Research office was completed and copies were made available to the attendees. The results were affirmative on shipboard recycling system, however, it recommended confining the process to commingled plastic rather than attempting to separate them.

- A concept paper was prepared for the Massachusetts Centers for Excellence (MCEC). The MCEC is established to stimulate economic development by promoting new technologies and new application of existing technologies industry, labor, academia and state government partnerships. Their areas of interest include marine science and polymer science. Natick expects to receive, as well as give, new ideas and information on merging technologies.

- A second IPA was developed for Dr. Stephen Orroth, also of the University of Lowell, to assist Dr. Lai. At this time activity is held in abeyance.

- The Technical Plan was rewritten to reflect the changes from the January meeting of the Plastics Steering Group.

- An article was published in "LINK", the newsletter of the R&D Associates. It was picked up and reprinted in "Packaging Digest". A news release was also prepared for the Natick Public Affairs Office. These are attempts to attract attention to the problem and hopefully find some solutions.

- A display depicting the problem was available at the R&D Associates for their meeting in New York City.

- An interesting briefing given by Battelle Columbus Laboratories was attended. During the briefing, a biodegradable plastic for use in the food industry was presented. According to Battelle it will be manufactured and in use in an unnamed fast food chain this summer. We will follow up.

Joel McCassie was then introduced and he discussed the activity on the packaging of milk, the paper cup, and meat wrappers.

Milk bladder
- Industry has shown considerable interest.
- Paperboard/paperwaxed containers identified as possible substitutes.
- Latex is also being look into.

Meat wrappers
- Currently industry is working on extending shelf life, at present it is 1-1/2 years.
- Different wrappers would affect shelf life making it shorter. That is not desirable to industry.
- a possible alternative may be a wax coating as commonly found on cheese.
- Further investigation is required.

Paper cup
- Industry has shown considerable interest.
- most "paper" cups are plastic lined.
- real "paper" cups are not conducive to hot beverages.

c. Ken Thompson, NAVSUP, distributed copies of and discussed his pamphlet, "PLAN OF ACTION AND MILESTONES", dated March 1989. He pointed out that the plan is developed in three sections: short, mid and long term actions. Each section identifies the number of the action, lead activity or code, description of the action, action required and and estimated completion date. Copies of the plan have been distributed by mail. He asked that those tasked report their progress to him by 1 July and quarterly thereafter.

d. The minutes of the last meeting of the Plastic Steering Group were reviewed, in particular, section 1 SUMMARY. The following was agreed to on the items as follows:

- Support to DTSRDC from Natick's Science and Advanced Technology Directorate (SATD) in the areas of microbiology and non-plastic food packaging. In the previous meeting it was agreed that specifics and funding would be discussed outside the meeting. No action has developed from this item and is dropped pending new developments.

- Fresh Fruits and Vegetable Wrappings. Action has been completed to integrate this into the system and is considered a closed item.

- Support to Natick RD&E Center. This item was for the Navy to provide to Natick an additional 173K for tasks to be completed in FY89. Changes in the program make this mute at this point and it is dropped.

- Prototype Recycling System. A land based proposal was discussed and the concept of a complete system from cleaning to separation was agreed to. The change to work further on the CMF is to be discussed at the meeting at NAVSEASYSCOM on 26 May 89.

- Tech Advisory Hit List. This item refers to the activity of the Plastic Working Group (PWG) which was approved at the previous meeting. The PWG had its initial meeting and will have its second following this meeting. Distribution of minutes is the same as for these minutes.

e. Victor Lachica, sitting in for Dr. Silverman, explained to the group the processes developed for another Natick project, Rail Garrison is concerned with the temporary storage of soiled waste from food. Their products include plate waste and is to be stored for five days. They are using a chemical, a spray deodorizer and a combination of the two. Progress will be reported as achieved.

f. Jean Mayer spoke on the meaning of 'biodegradable' and cautioned that the term is used very loosely. Manufacturers of wrappings or plastic bags are referring to their products as biodegradable when, in fact, only a small portion is. When the portion that is lets go the rest of the plastic remains. A true biodegradable breaks down through the action of living things, such as, microorganisms.

g. General comments and points made were as follows:

- It is important to keep the project and its goals visible for support and solutions.

- At the present time it appears industry has no motive to change from plastic to other materials.

- There have been some adverse effects of advertising degradable products. The public may assume that since they are degradable the public is encouraged to litter.

- Despite equipment to process waste plastic it is of major importance to continue a max effort to reduce the input.

- Chopping plastic into particles may cause FOD concerns.

- The weight of a 'brick' product must be considered in design of equipment.

- The American Plastics Association (APA) has developed a symbol/number system to distinguish different plastics. Compliance is voluntary.

- The next meeting is targeted for the second week in November in the Washington D.C./Arlington, VA area.

<u>NOTE</u>: At the meeting in Washington on 26 May 89, two decisions of significance were arrived at. First, development of any hardware associated with this project will be developed by the David Taylor Ship Research and Development Center. Second, the Plastic Steering Group will no longer meet, the Plastic Working Group will continue under the auspices of Natick RD&E Center.

Minutes of Meeting
for the
Plastics Working Group

4 May 1989

1. Mr. Joseph Wall, PRIME project officer for the Natick RD&E Center, began the meeting by reviewing the purpose of the group. Its stated purpose is to identify plastics in the supply system that should be eliminated and substitutes found. Focusing a that goal, group members are asked to use their resources to furnish relevant information and to assist Natick or others in accomplishing this task.

2. The members of the group were identified as follows:

Natick RD&E Center:
Joseph M. Wall, Natick PRIME Project Officer
Stephen Rei, Data Base Manager
Joel McCassie, Packaging
Gerald Silverman, Microbiology
Betty Davis, Specifications

NAVRESSO:
John Dixon

COMNAVAIRPAC:
Jerry Parks

DPSC:
LTC James Elmore

NAVSUP:
Kenneth Thompson

NAVFSSO:
CMDR John Hartman
LTJG John Rogers

CINCLANFLT
CMDR Fred Chitty

DLA:
Becky Barker

GSA:
Tom Rogers

Of the above, NAVRESSO and CINCLANFLT were not present. NAVRESSO did provide input through NAVSUP.

3. At the meeting in January a number of items were identified and that list was reviewed.

<u>Hot drink cup/Natick</u> - Natick has been in contact with paper converters producing paper cups, two companies (Westvaco and Pressware) have expressed interest in the PRIME and Army field feeding programs. Meetings have been scheduled for late May. Both companies currently produce cups that have a thin polyethylene lining, by substituting for a 'natural' wax lining they may meet our requirements. Other topics discussed in this area were (1) Flavor transfer from an unlined cup or from the lining itself, (2) The acceptability of a non-white (natural Kraft color) cup, (3) The feasibility of sailors having their own permanent cup and dealing with the associated regulation, and (4) Also discussed was development of a PRIME related purchasing base for PRIME specific goods.

<u>Milk bladder/Natick</u> - Natick has contacted three major suppliers (Scholle Corp., Liqui-box, and Rehrig Pacific) as to the possible substitutes and developmental items that may help our effort; responses were negative. There is not an off-the-shelf substitute for the milk bladder. Natick is

investigating a possible R&D effort with ILC Corp. to develop a natural latex substitute. Another topic discussed was the substitution of a one gallon paperboard carton that is currently available and the ramifications on current galley systems. Current galley systems use a 5/6 gallon container.

Meat wrappers/Natick - Current technology in the meat industry is moving toward the increased use of plastic materials to preserve and extend the shelf life of meat and deli items. Several possibilities that require further investigation include (1) Accepting reduced shelf life meat items packed in a waxed form similar to cheese products, (2) Requiring all deli items be made with edible casings rather than plastic ones. The group also discussed the inclusion of fish and seafood wrappers as part of any future investigation.

Absorbent rags - Evaluations on various alternatives have been conducted. Kimberly Clark has a product that meets the requirements. 'Kimwipes' have been used successfully on the Ranger and the Texas. It was pointed out that although a product appears to be non-plastic it requires close examination to be sure. In one instance it was found that the threads holding pieces together were plastic. A CID is available and a copy is attached.

Plastic trash bags - NSCs now have local purchase authority to buy other than plastic. A 30 gallon wet strength paper bag is available for the galley. There is also a 7 gallon bag suitable for waste baskets.

Six pack rings - Reduction now stands at 60%. By the end of the calendar year NAVRESSO hopes to achieve a reduction of 90%. In addition to the six pack ring, NAVRESSO has sent a letter to 36 suppliers of Ship's store merchandise requesting that they review their packaging methods and advise if plastics were used; how it is used, and if it could be replaced or eliminated. 36 replies were received

Summary of responses:

Don't plan on changing at this time	3
Partial change/reduced usage	3
Could change/replace, will advise	2
Use discontinued based on NAVRESSO letter	9
Will discontinue by 12/89	3
Do not use plastics	16
TOTAL	36

Plastic flatware - Some wood products have been looked at but wood does not look promising due to safety and strength. A better solution appears to be in developing methods to wash regular flatware at ambient temperatures.

Individual portion pack vs bulk - Ships have been advised to order the bulk items in lieu of the individual portion pack. This item is considered completed.

List of items in both plastic and non-plastic - DPSC reviewed the Type Pack 2 standardization documents to identify those which permit non-plastic alternative packaging, packing, or unitization. As a result the Type Pack 2 is being scrubbed to eliminate items without Navy interest and to modify format to enhance readability. DPSC is also developing a market survey on those Type Pack 2 items with non-plastic alternative packaging to determine the scope of commercial practice, cost differences and potential procurement problems.

Natick is compiling a list of specifications that have potential for change. Each will be reviewed as to the options in packaging. Results will be reported. (Some of the items observed during ship's visits that were available in both plastic and non-plastic wrap were spices, sugar, frozen vegetables, sardines from Norway and various items of produce; some items mentioned by crew were the scraps from engraving labels on doors and plastic wrap on batteries used for emergency lamps.)

Work on all the above, except the individual portion vs bulk is continuing.

4. Mr. Parks, COMNAVAIRPAC, spoke of his observations on a recent deployment of the USS Ranger from San Diego to Pearl Harbor. For 21 days plastic was separated and stored on the fan tail and off loaded in Hawaii. The galleys had their particular problem in that the garbage disposals were not working requiring that plate waste be carried to the fan tail and dumped. He remarked on how successful the experiment had been. The cooperation was outstanding. The crew separated the plastic from the other trash into 1200 green containers provided to the various sections for that purpose. Section stored the plastic waste where ever they could. Some ingenuity was noted in areas found to stow it. Additionally, when the plastic was brought for disposal, the section chief signed that the trash going overboard was plastic free. The heads, being unattended, proved to be the most difficult to monitor.

The wet strength paper bag was used in the galley and was considered successful. However, when filled with hot wet trash it was challenged. It did not break or leak but it was wet. Because of this and to preclude any breakage when being carried over the decks a plastic bag was used as a shell. The shell was retained and reused. 600 of the thirty gallon size gags were used daily.

Mr. Parks indicated that at the present rate the Pacific fleet will not make the December 1992 deadline. The group consensus was that it would be one thing not to comply with a public law but quite another not to comply with an international treaty commitment. It was concluded that this fact should be raised to the highest levels at this time.

A much used item is the sonar buoy. It comes in a plastic container that appears to be reusable but is not. The markings on the container such as, "military use only" or "Danger" create apprehension on the part of refuse collectors suggesting to them that the container itself is dangerous. It was suggested that procurement documents take into consideration the responsibility for disposing of such plastic containers in procurement documents.

5. In general discussion:

Ms. Barker - efforts are being pursued to replace all styrofoam dunnage with Kraft paper or the like.
- there are many avenues to pursue, some of these are wrappings on items like T shirts and hardware items.
- DLA intends to give full support to the program.

Mr. McCassie - suggested that a PRIME clause be entered in solicitations as an incentive to comply willingly.

Mr. Thompson - said that a DFARS clause is being pursued but will likely take 2-3 years.

Mr. Rogers - GSA uses a Value Incentive Clause. GSA supports the program 100%.

The next meeting is scheduled for early November in tandem with the Plastics Steering Group.

APPENDIX B

Independent Review of Proposed Recycling System

1. **Plastic Removal in a Marine Environment (Rutgers University)**
   C. Neal Merriam
   Thomas J. Nosker
   Richard Renfree

2. **Reclamation of Post-Consumer Plastics Packaging Wastes in the United States (Rutgers University)**
   Darrell R. Morrow
   Thomas Nosker
   Sidney Rankin

3. **An On-Board System for Processing Post-Consumer Waste: Rationale, Objectives, Approaches (University of Lowell)**
   F. S. Lai

1. Plastics Removal in a Marine Environment

by

C. Neale Merriam
Thomas J. Nosker
Richard Renfree

Center for Plastics Recycling Research
Rutgers The State University of New Jersey
Building 3529 - Busch Campus
Piscataway, NJ 08855

February 5, 1989

Contract No. DAAL03-86-D-0001
Delivery Order 1259
Scientific Services Program

SUMMARY

The University of Lowell's program to recycle plastic wastes on ship board is reviewed. No new basic technology is required to meet the objectives, but developing a "shipboard" compatible system will be very difficult.

It is suggested that a commingled stream be handled in the system rather than separate out any individual plastic component.

INTRODUCTION

Water insensitivity of plastics, bulk density less than that of water and low rates of degradation in the marine environment cause long term litter in all waterways as well as contamination of the shorelines. Some plastic packaging materials discarded from shipboard have been observed to have caused death in several species of marine life through purely mechanical interference of normal digestive cycles.

To eliminate the dumping of plastics in the marine environment, 29 nations have signed a treaty with full compliance scheduled for 1993. To comply with the U.S. commitment, the U.S. Navy is investigating an on board plastics recycling system.

Storage of plastic trash on shipboard with subsequent recycling on shore must address the major problems of high volume and sanitation. Consolidation of this low bulk density plastic trash by means of thermoplastic processing would address both of these concerns as well as providing an intermediate plastic product which could enter on shore recycling more readily.

DISCUSSION

Recycling from trash requires a number of steps to ultimately return a material for a second cycle of use. Separation from other undesirable materials, purification or reclamation, fabrication and the final step of useful application. The first two stages are easily perceived to be accomplished on shipboard.

In Figure 1, the Plastic Waste Recycling System as presented by the University of Lowell, will be reviewed. To feed the system, manual separation of plastics from other materials is required. A combination of flexible packaging, rigid plastic containers and foam plastics generated throughout the ship would be brought to the consolidation area.

Initial cleaning is preferably done at the point of generation and separation such as rinsing in the galley or draining of oil containers in the engine room. From our viewpoint an extra, separate cleaning step may not be needed since minor residual foodstuff which develop odor and bacterial growth would be sanitized and destroyed during thermoplastic processing .

Lowell has suggested a classification step to handle a complex plastic mix which leads to multiple streams. Subsequently, the separated streams will be processed in parallel pieces of equipment or stored separately and extruded sequentially. This may not be necessary, depending on the composition of plastics on board ship. In a large land based recycling facility it is feasible for separation into a number of

generic plastic streams to maximize the value of the products. Because of the small amount of each plastic type generated and the numerous varieties of plastics encountered, the type of plastics recycling recommended on shipboard is commingled. This process is capable of reducing the number of streams of plastics to be processed to one, in most cases, (again depending on the composition aboard ships). It remains to be determined whether the high temperature processing step should take place on board ship or at a centralized land based facility. Reasons for this question include the lack of markets for repelletized commingled plastics and lack of available space on board ships. The technology for this process should, however, not interfere with Lowell's projected scheduling.

While not explicitly shown in the Lowell schematic, some kind of a shredder or granulator will be required to reduce the variety of sizes and shapes of the plastic materials for feeding any type of extruder. Also, a film densifier may be required if it is determined that large volumes of plastic film are a part of the ships waste stream. While a number of pieces of equipment are commercially available for attrition, reduction to shipboard recycling size will be a challenge. The knowledge, experience and laboratory equipment at Lowell are fully qualified to address this problem.

The reason for two extruders depicted in the recycling schematic is fully appreciated by the reviewers. Thermal stability of polyvinychloride polymers are not adequate at temperatures necessary for the fusion of polyesters and nylon

present in packaging. Extrusion and compounding should be limited to 200°C (375°F) which allows fusion of perhaps 90% of the plastics in the municipal trash stream (reference-CIPCON paper attached). The minor portion of unfused PET and nylon would exist as particulate filler. A compositional analysis should be carried out at an early stage to verify if shipboard plastic is similar to civilian trash.

The extruded pellet of the commingled stream of plastics will have an estimated bulk density of 30 to 40 lbs. per cubic foot as compared to plastic packaging waste of 2 lbs per cubic foot. On shore the pelleted material would only have a value approximately equal to transportation costs to a fabrication facility making large bulk structures such as landscaping ties, fencing and rough style outdoor furniture.

CONCLUSIONS

- Plastic recycling of waste plastics on shipboard is technically feasible.
- No unusual processing principle need to be demonstrated, but reduction in size, scale and cost of equipment for shipboard use may limit a practical solution.
- Separation into several different types of plastics is not recommended due to the increase in the complexity of the system and an unlikely compensating increase in the value of the separate plastics.
- The facilities and personnel at the University of Lowell are more than adequate to meet the objectives of this proposal.

- Task 1a, starting at the beginning of the project, should be to accurately determine the volume of plastics waste expected from the different sizes and types of naval vessels.
- Concurrent with task 1 should be a survey of the facilities to be made available on the different types of naval vessels (including power availability and space). This knowledge, along with information on the volume and types of plastics wastes from each type of ship, will allow a determination of whether only one size (type) of plastics recycling system needs to be designed or if the system must be tailored to each ship.
- Task 1 is very critical to the design of the shipboard plastics recycling system.
- Task "2A" starting at month one should be added to the proposed program (Appendix A). Task "2A" would be the immediate pilot testing of the plastic waste stream in existing pieces of processing equipment at Lowell and vendors.
- Clarification of Task 3 on the question of design is necessary if the time schedule is to be met. If design means assembling and connecting individual machines into a system, the 3-6 month is feasible. Any major modification or design change of individual units would be unlikely in such a short period.
- We believe that the chance of success is less than 50% at the present time. At the conclusion of task 1 a better

estimate can be made by this team. Each individual step in the recycling system has been or is in use. The major question is the space, capacity and cost limitations which will vary from ship to ship. At this point the absolute amount of material to be processed in a unit is not clear. If only 100 to 200 pounds per day are handled the cost and necessary processing space would be prohibitive.

- If a completely commingled plastic waste approach is used, it is conceivable that a single piece of machinery with high mechanical energy input for size reduction would do the "job". Cutting, tearing, grinding and shearing modes during size reduction would generate heat for particle fusion. Controlling energy rate input and cooling, an acceptable crumb might result. This approach was touched on during the visit to Lowell. Lowell personnel are familiar with equipment of this type.

2. Reclamation of Post-Consumer Plastics Packaging Wastes in the United States

Darrell R. Morrow, Ph.D.
Thomas Nosker, Ph. D.
Sidney Rankin, Ph. D.

ABSTRACT

The current waste disposal crisis in the United States is increasingly leading to attacks on plastics packaging wastes, since these post-consumer waste materials are perceived to be a major cause of the problem. Virtually overnight, municipal solid waste officials in many parts of the country have discovered that they are rapidly running out of viable landfill space; and further, that waste-to-energy incineration capacity is not being installed at a sufficient rate to handle the increasing quantities of municipal solid wastes. The quantity of municipal garbage is growing, largely due to increases in packaging which stem from lifestyle changes in the U.S. Much of this packaging is made of plastics. There is a growing belief among legislators that materials that are perceived to be non-recyclable should not be permitted to grow in the market-place, and therefore should be restricted or banned. Plastic recycling, therefore, is a technology for which there is a real need that must be satisfied in a timely fashion.

The Center for Plastics Recycling Research (CPRR) at Rutgers, The State University of New Jersey, is a growing industry/government/university cooperative research program established for both the development and dissemination of

technology and information relating to the practical recycling of what would otherwise be plastics wastes. The CPRR, funded primarily by the Plastics Recycling Foundation and the New Jersey Commission on Science and Technology, is charged with performing the required research, development, and engineering that will enable all plastics to be collected and recycled to their highest economic value and with appropriate environmental benefits. A twofold approach to plastics recycling technology has been adopted:

1) Development of processes which can take dirty, used, separated plastic bottles and recover a clean, usable, generic polymer resin for reuse, and

2) The study of processes which take the residual mixed plastic stream and make useful products from them.

These two approaches are outlined and explained in detail.

THE RECLAMATION OF POST CONSUMER PLASTICS PACKAGING WASTES IN THE UNITED STATES

By Darrell R. Morrow, Ph.D.
Thomas J. Nosker, Ph.D.
Sidney Rankin, Ph.D.
of The Center for Plastics Recycling Research
Rutgers University, New Jersey, U.S.A.

Many parts of the United States are currently experiencing a waste disposal crisis. This is the result of a trend of increasing solid waste disposal on a per-capita basis over time, and the diminution of land for people to live on in certain heavily populated parts of the country. The practice of simply landfilling almost all solid wastes was established many years ago as a result of relatively few people inhabiting a large and prosperous land. We are just now realizing that this practice represents a bad habit, and are attempting to change this habit. One important step we are undertaking toward achieving this change is the development of systems for the reclamation of post-consumer plastic packaging wastes in our country. The Center for Plastics Recycling Research (CPRR), an organization dedicated to the advancement of plastics recycling, is charged with performing the needed research, development, and engineering that will enable all plastics to be recycled to their highest economic

value and with appropriate environmental benefits. The CPRR is also responsible for disseminating these technologies as they are developed. The task of developing effective plastics recycling systems is well underway, but far from over.

Each person in the U.S. generates, on the average, 1,000 lb/yr of trash (1). Nearly all of it is put in landfills, but these are filling up. A recent U.S. Government survey showed that at least 27 states will face severe landfill problems in the next two to nine years (2). In 1979, there were 18,500 active landfills in the U.S. In 1986, the number of active landfills had fallen to 9,283, due to the combination of lack of capacity, the high cost of disposal, the remoteness of new landfill sites, and citizen opposition (3). Approximately one-fourth of major U.S. cities will have used up their existing landfills in the next four years (Los Angeles by 1991 and New York City before 2000).

Some communities in the Northeast part of the country pay as much as $150 per ton to have their garbage transported to landfills in other states (4). The average cost was $10 per ton 10 years ago. As the figures indicate, this problem is a rather serious one, and the public is paying a high price for dealing with it. The weight percentage of plastics in the U.S. waste stream has increased from 2.7% in 1970 to 7.2% in 1984, and this figure is predicted to rise to 9.8% by the year 2000 (5). Of course, when solid waste is landfilled, it occupies volume, so a more important comparison of types of materials in the waste stream would be a volume percentage. The volume percentage of plastics has recently been estimated to be 30% in the U.S., and

23% in Europe (6,7). These facts, coupled with the resistance of plastics to degradation in the landfills, have created a belief among legislators that either plastics recycling should be instituted on a large scale, or that plastic packaging should not be permitted to grow in the marketplace, and therefore should be restricted or banned. The Center for Plastics Recycling Research was founded to help deal with this problem.

Plastic containers are made in the U.S. out of many different types of materials, but some industries have standardized to the point where generalizations may be made. Plastic milk bottles, for instance, are manufactured from un-pigmented high-density polyethylene (HDPE). Plastic carbonated beverage bottles are made from polyethylene terepthalate (PET). Small differences occur between specific plastic carbonated beverage bottles. Some of them have base cups made of HDPE, and others do not. Some have aluminum caps, and others have HDPE caps. The label is made of paper or polypropylene (PP) attached to the bottle by means of adhesives which are usually based on EVA (ethyl-vinyl acetate copolymer). Plastic bottles are also used for household cleaners, cooking oil, foods, and the like. these other types of bottles may be made of HDPE, PET, polyvinyl chloride (PVC), or polypropylene (PP). Bottles in these applications are not very well standardized as to type of material for each product; and manufacturers frequently specify the color, shape, and material of their bottles. An understanding of the makeup of the plastic waste stream and the economics of the plastics industry were necessary at the CPRR to

make an educated decision as to what approach to plastics recycling would be the most logical one, (see Figure B-1).

Initially, attention was focused on the development of a process that could take dirty, used, separated plastic bottles and recover a clean, usable, generic polymer resin for reuse. The PET carbonated beverage bottle became the focus for this system because of the relatively high value of that resin, and the availability of bottles, (24.1% of the plastic bottle market by weight, 2). A large scale pilot plant facility was established at Rutgers that is capable of accepting all types of used PET beverage bottles, (including HDPE base cups, aluminum caps, labels, adhesives, and dirt), and/or HDPE beverage bottles as a feedstock; and that can convert this feedstock into (a) a clean, high purity, reusable granulated PET product stream, (b) a clean, reusable granulated HDPE product stream, (c) a clean aluminum rich product stream, and (d) waste streams containing food wastes, label wastes, and dirt. The feedstock may be in the form of whole bottles, baled bottles, shredded bottles, or pre-granulated bottles. The process is not sensitive to polymer color. If the feedstock contains bottles of mixed colors, the product streams will be of mixed colors.

The CPRR PET beverage bottle reclamation process consists of the following steps designed to separate post-consumer (used) PET beverage bottles into clean salable products:

1. Reduce the bottles to chips of 1/4-5/16 of an inch maximum size, using a rotary knife granulator, or a

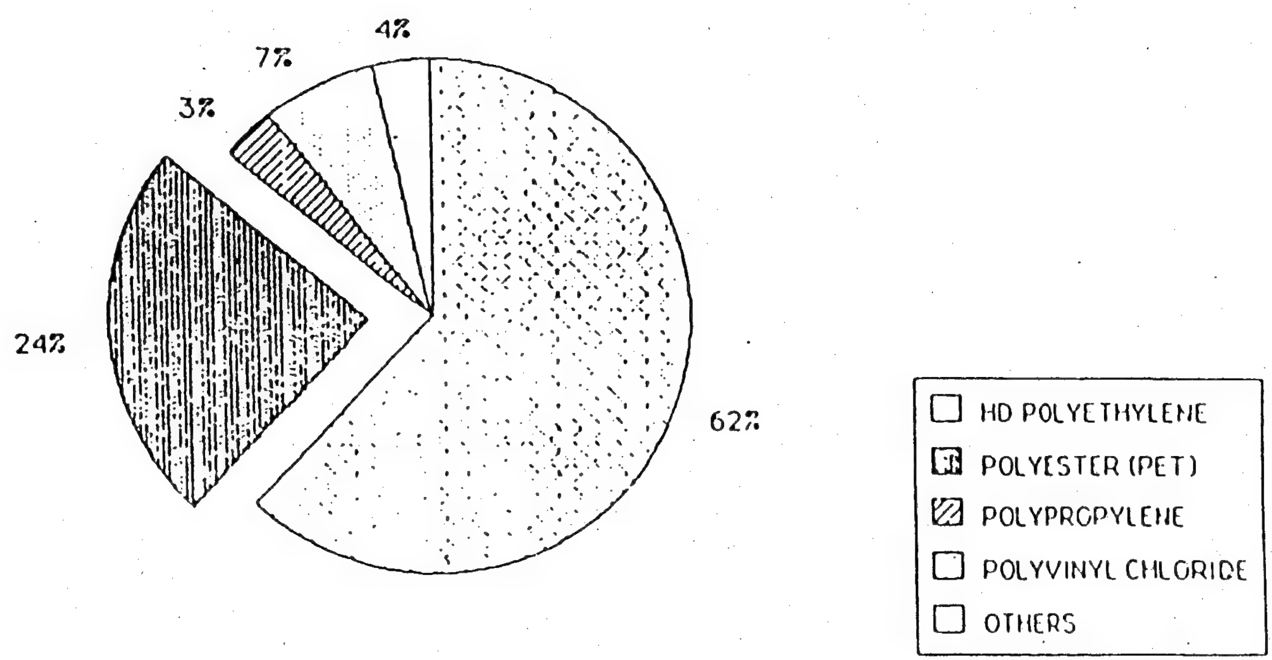


Figure B-1. Plastics in Bottles - 1986 (2.9 billion pounds)

two-step combination of a shredder followed by a rotary knife granulator;

2. Remove loose labels and dirt through air classification;

3. Wash the dirty chips in a hot agitated detergent wash solution;

4. Drain and recover the wash solution, and rinse the washed chips;

5. Float separate the lower density HDPE fraction from the higher density PET/aluminum fraction, in a water filled flotation chamber;

6. Dry the HDPE fraction and package for resale;

7. Dry the PET/aluminum fraction and direct it to an electrostatic separator for removal of the aluminum from the PET, and;

8. Package the PET and aluminum product streams for resale.

Figure B-2 is a schematic of a recycling plastic processing plant.

Studies have been made as to the best equipment for the operation; and considerable time, money, and effort have gone

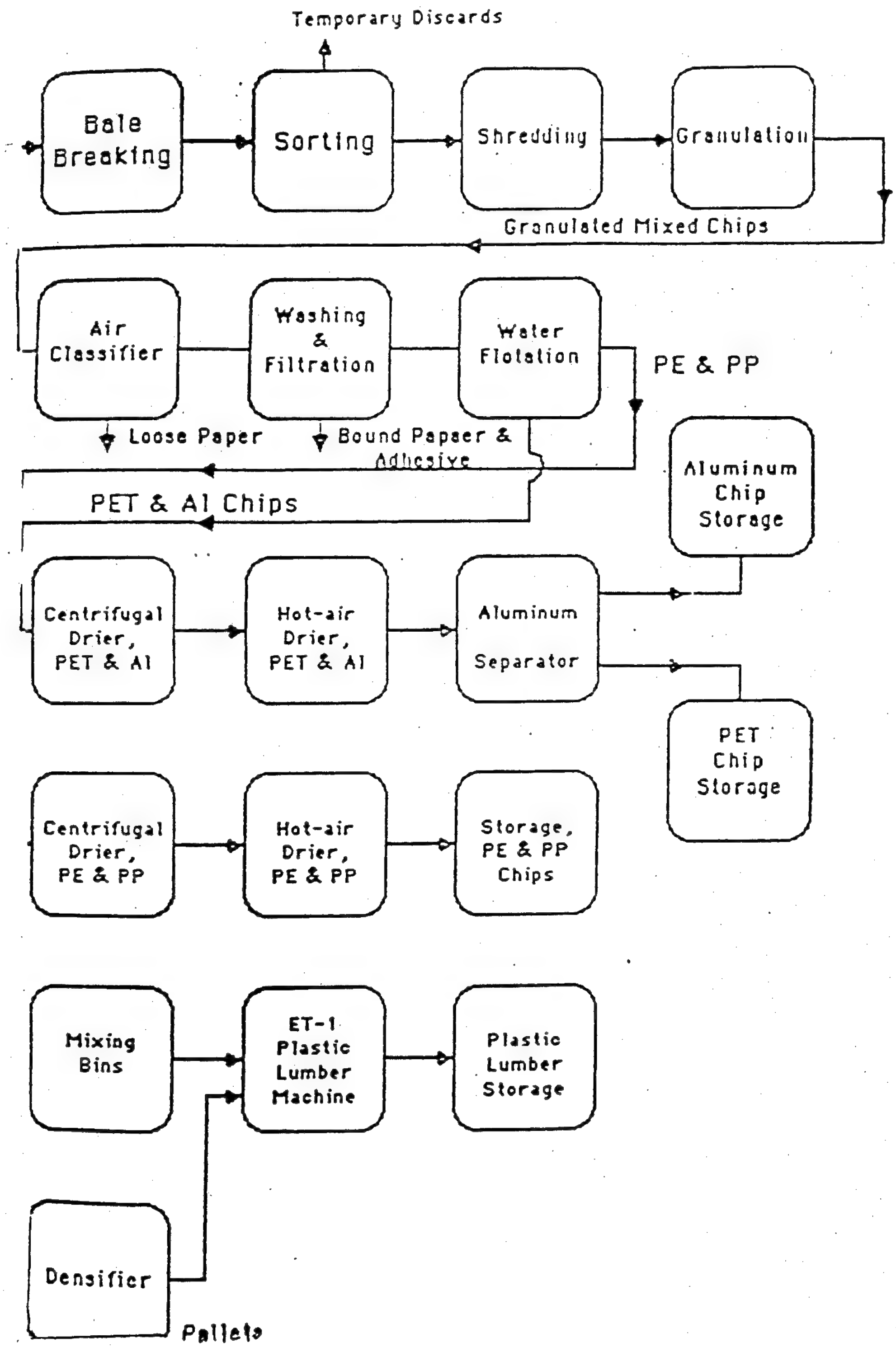


Figure B-2. Recycling Plastic Processing Plant

into the optimization of this process. Since part of our responsibility includes that the technology be disseminated; in September, 1987 the process was made available to the public in a Technology Transfer Manual for the process, revealing the process in intricate detail, along with an economic analysis of the process. This manual is available as part of a licensing agreement for the CPRR process.

The CPRR plastic bottle recycling process washes the mixed chips at a low temperature with a non-caustic detergent, so it could be expected that the polymer chips will not be degraded. Experimental test results of molecular weight, intrinsic viscosity, and couette geometry viscosity measurements performed on virgin material, the CPRR product, and dirty chips indicate that the CPRR process does not degrade the PET, and that clean chips emerge from the process. The PET-rich stream is 99.97% pure PET.

When the process was in the development stage, the price of virgin PET was approximately 54 cents per pound, while virgin HDPE sold for under 25 cents per pound, making the PET resin by far the most valuable bottle resin. Recently this situation has changed drastically. With the recent increase in price of all polyolefins, HDPE resin prices are now rapidly approaching those of PET. Fortunately, the CPRR resin recycling system is capable of accepting HDPE bottles along with PET bottles, simply separating the different plastic components as part of the design.

There are many other types of plastics bottles that are not

easily identifiable (and therefore not easily separable) as to the resin type used in manufacture, and indeed, it is difficult to determine if the bottle is made of a homopolymer. To try to separate these bottles by resin type would be very difficult and expensive, and the resulting bottles would not collectively be of great value due to the varied pigmentations used in manufacturing. To utilize the CPRR process for the recycling of this portion of plastic waste would not solve the problem associated with these remaining plastic bottles in the solid waste stream. In addition, the resin recycling process does not address the issue of plastics film wastes, or other types of waste plastics packaging. Another approach was deemed necessary to deal with these forms of plastics wastes.

The technology which has been developed to deal with mixtures of plastics wastes is called commingled plastics technology. Processes for manufacturing products from mixed plastics wastes have been developed in Europe, but have not been extensively studied from a scientific point of view. Basically, these commingled plastics processes take the residual mixed plastic stream and make useful products from them. From a polymer science point of view, such a diverse combination of plastics in this mixed plastics bottle stream are not considered to be capable of "blending", or interacting on a molecular level to form a continuous structure. However, this mixture can be processed into bulky, large cross-section objects that indeed have some utility. Of the very few available pieces of equipment obtainable in this field, the CPRR chose to obtain an ET/1

to the more traditional wood or cement products, there are many possible advantages of these materials. Plastics are well-known for their durability and weather resistance in the presence of moisture and the elements. We are currently researching this topic, and are heavily involved in choosing the correct markets for commingled waste plastics products.

Additional areas of research at the CPRR include the study of effective means of collecting plastics wastes from the waste stream for processing. While this study is probably the least scientifically technical, it is also probably the most complex to completely understand. Currently, systems exist across the U.S. which meet with varying degrees of success. The most successful of these systems appear to be source-separated systems, where house holders separate the recyclables from their non-recyclable garbage, and collectors keep these streams separated. Eventually, the recyclable stream is further separated by type at a Materials Recovery Facility (MRF).

BIBLIOGRAPHY

1. Kenneth Brooks, Anne Watzman, Garbage Disposal: To Burn or Not to Burn, Chemical Week, June 11, p.44&47 (1986)

2. Anonymous, Disposal Crisis Coming? State-by-State Answers, Waste Age Magazine, Jan. pp.57-64 (1987)

3. Richard Keller, Key Elements in a Recycled Paper Purchasing Program, Paper presented at the New York Legislative Commission on Solid Waste Conference, held Feb. 11-14, 31 pages, New York City (1987)

4. Kate Mahar, Recycling Pressures Mount, Beverage Industry, July, P.1,20,24 (1987)

5. Franklin Associates, Characterization of Municipal Solid Waste in the United States, 1960 to 2000, a report prepared for the U.S. Environmental Protection Agency, 71 pages, (1986)

6. Estimate from Jack Schlegel of International Plastics Consultant Corp., Stanford, Conn. which appeared in Modern Plastics, Jan., p.25-26, (1988)

7. J. Claerbout, Progress for Post Consumer Plastic-Waste Recycling, a paper presented at the Institute of Waste Management, London Centre and Southern Counties, Nov.23, London, England, (1987)

3. An On-Board System for Processing Post-Consumer Waste: Rationale, Objectives, Approaches

F. S. Lai

University of Lowell, Lowell MA 01854

ABSTRACT

Rationale

The scarcity and cost of raw materials, as well as the environmental issue, make recycling and reclamation of plastics an imperative consideration. Marine vessels, from which tons of plastic waste are dumped overboard daily, are undergoing modification to end ocean disposal of nonbiodegradable trash. A recent treaty signed by 29 nations bans plastic dumping at sea and establishes tight restrictions on other ocean trash disposal. The U.S. Navy has agreed to full compliance with the treaty by 1993, except during wartime or national emergencies. It is, therefore, imperative that a sensible, economic, and feasible plastics recycling system be developed for a ship.

Objectives

The objectives of this project are:

1. To conduct systematic investigation of a plastics on-board recycling system based on a set of logical and practical criteria.

2. To investigate the feasibility of such a system.

3. To conduct and test the system on land in a simulated ship environment.

4. To implement the successful system on a ship.

Approaches

A system for processing post consumer plastic waste is capable of extruding pellets for further uses as raw material. An on-board system not only reclaims the waste but also reduces the volume of the waste. The concept of the system are given in Fig B-3. The waste may be presented to the system in an extremely wide range of bulk densities, particle shapes, chemical compositions, contamination levels, and dryness. The variety of feed stock can include utilized materials such as wrapped films, fibers and foams, irregular granulated molding or sheet stock, highly contaminated feed and wet abrasive materials. Plastics that are source separated from the waste are preferred for economic reasons. If a plastic is heavily contaminated with wet organic waste, it may require a simple washing process with sea water.

The project approach is to synthesize a plastic recycling system at the University of Lowell. The system will be eventually installed on board a ship. The experiment includes synthesizing available processing equipment and

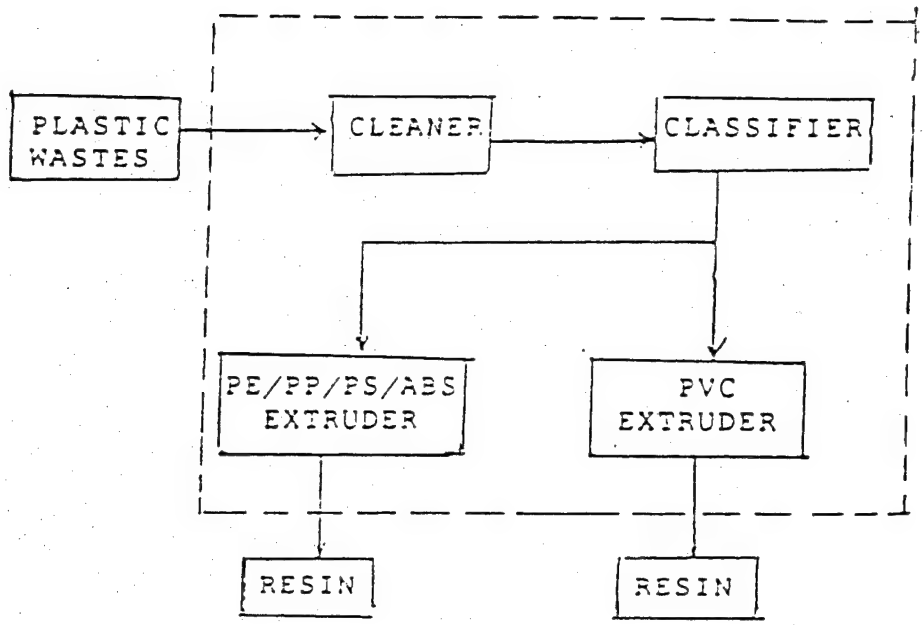


Figure B-3. Plastic Waste Recycling System

designing new system components. This process is time consuming and tedious. It is feasible only in university environment with industrial cooperation.

In order to accomplish the work in an efficient and timely manner, the overall project has been divided into six principal tasks. A schedule of task is given below.

Task 1. Collect Data and establish the pattern of plastics waste on a ship (Months 1-2).

We plan to work closely with the researchers at the U.S. Army Natick laboratory to collect the data of plastics waste on a ship. The data will provide a general composition of plastic waste. The determination of the composition will enable us to design a proper recycling extruder and densifier system.

Task 2. Collect the plastic wastes (Months 1-12).

The U.S. Army Natic laboratory will assist us in collecting typical plastic wastes to be recycled. The waste will then be used in the laboratory for the experiment.

Task 3. Design and Construct a Plastic Recycling System(Month 3 - 6).

Based on the data obtained in Task 1, a recycling system will be synthesized and constructed. A data acquisition system will also be installed to monitor processing variables.

Task 4. Critical Test Run(Month 7 - 12)

Data will be taken during the six-month period for consistent testing of recycling plastics waste. Experience gained during the period will provide the knowledge to design a practical on-board plastics recycling system.

Task 5. Verification of the Capability of the System and Design of the System(Month 13 -15)

This task will include a detailed design of a real experimental recycling system on-board a ship. A final report will also be prepared during the period.

Task 6. Installation of the system on-board a ship and testing(Month 16-24).

This task will install a system on a ship. All the pertinent data will also be monitored.

APPENDIX C

A Discussion of Pyrolysis of Plastic Waste

F. S. Lai, University of Lowell, MA

PYROLYSIS

Pyrolysis means thermal splitting of organic molecules in the absence of oxygen. If polymer is burned in an oxygen rich atmosphere, as in the case of incineration, carbon dioxide gas is produced. This is the lowest or most regressive ecological energy level. In other words, this gas can make no positive contribution to our energy resources. However when the polymer molecule is 'burned' in an oxygen-free atmosphere, the produced pyrolysis gas is, in reference to ultimate resources conservation, ecologically less regressive than the combustion products from incineration. Pyrolysis converts plastics waste to products with a potentially positive energy contribution rather than carbon dioxide. Hence pyrolysis is the most preferred among the available recycling processes of tertiary and quaternary nature.

SUITABILITY OF PYROLYSIS

Pyrolysis is a recycling process for a wide variety of materials, especially for plastics waste of different origins. The average composition of plastics waste suitable for pyrolysis may be approximated as:

60% Polyolefins

20% Polystyrene

15% PVC

5% Other

Besides plastics, the following substances are also suitable for pyrolysis:

Paper, Wood, Rubber, Textiles, Garbage (food wastes), Sewage sludge.

FLUIDIZED-SOLIDS PROCESSING

If we can ascribe one characteristic to plastics waste materials which significantly affects waste control techniques, it would be the extreme variability of waste materials. It follows therefore that any method that can properly treat waste materials has to be a method that can be adapted to rapidly changing conditions. This is a premier characteristic of fluidized-solids processing.

Mechanism of Fluidization

The fluidized bed is simply a cylinder containing a bed of high silica sand resting on a gas distribution plate. Compressed gas passes through the distribution plate and into the bed suspending each solid sand particle. The fluidized bed operates at practically isothermal conditions and any solids introduced into the bed will immediately attain the temperature of the sand. This characteristic allows for rapid and complete combustion of the solid waste particles. The heat of combustion is immediately carried away by the fluidized sand to be used elsewhere in the bed. The fluidized sand thus acts as a thermal flywheel in that it supplies the heat of reaction to allow the solid waste to burn and then removes the heat of combustion to another area of the bed. It is primarily for this reason that fluidized-solids processing is preferred for the pyrolysis of plastics refuse.

Mechanism of Fluidized-bed Pyrolysis

The process of pyrolyzing the plastics refuse is conducted in a 650 to 750 deg. C (1200 To 1380 deg. F) fluidized sand bed in an oxygen-free atmosphere. the polymer molecule is introduced into the bed as plastics refuse and the thermal flywheel effect

immediately brings the refuse to 650 To 750 deg. C; where the polymer molecule will burn. Due to the absence of oxygen in the bed atmosphere, the molecule instead of burning actually explodes. In this explosion, as in any explosion, the molecule is randomly blown apart. The fragments of the exploded polymer molecule form the crude pyrolysis gas. A simple representation of this process is shown in Figure C-1.

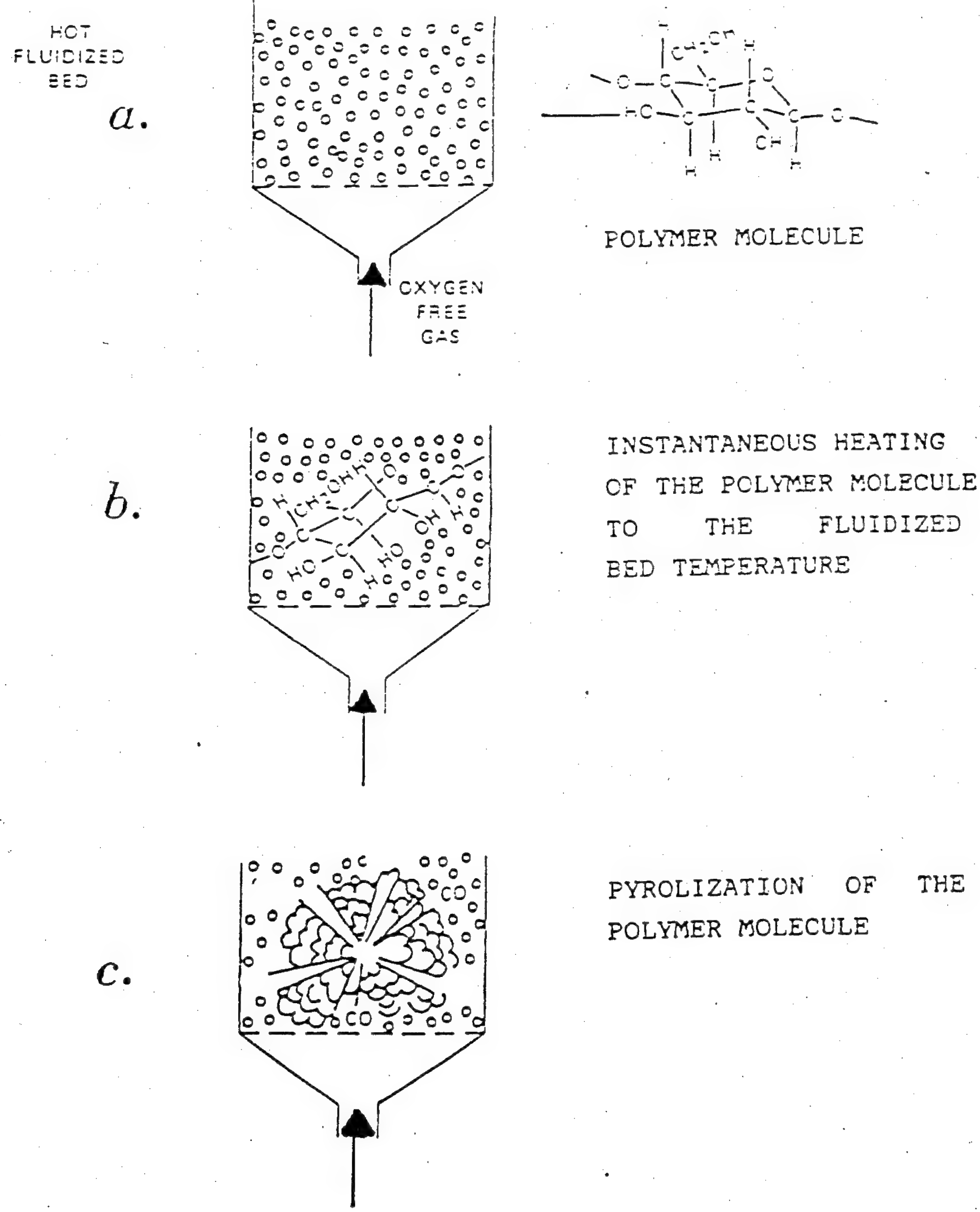


Figure C-1. Chemical Reduction of the Polymer Molecule.

Figures C-1a and C-1b show the polymer molecule being introduced into the hot fluidized bed.Figure C-1c shows the polymer molecule literally being rearranged by exploding into its pyrolysis gas products.

GENERAL PROCESS DESCRIPTION

Step 1: The shredded plastics waste is thermally split in the pyrolysis reactor (in the absence of oxygen) at a temperature of between 650 & 750 deg. C (1200 & 1380 deg. F). This splitting process is performed in a fluidized bed of quartz sand. Thanks to the good distribution of the waste in the fluidized bed, the uniform temperature obtained there, and the good heat transfer from the indirect heating system via the fluidized sand to the plastic, short splitting times are attained, and a uniform product quality is achieved. The non-pyrolysible foreign substances, present with the plastics waste collect in the bottom part of the reactor, and are removed from there.

Step 2:

The crude pyrolysis gas is purified from soot and sand residues in a cyclone.

Step 3: Heavy pyrolysis oil condenses when the crude gas is cooled down to 150 deg. C in cooling stage 1.

Step 4: During a further temperature reduction in cooling stage 2 down to 1 deg. C, all valuable aromatics are condensed and the light pyrolysis oil is obtained.

Step 5: In a downstream scrubber, the remaining pyrolysis gas is passed in counterflow against the light pyrolysis oil, in order to wash out the last liquid components remaining in the gas.

Step 6: The light pyrolysis oil also contains the water, admitted together with the plastics waste. These are separated by means of their varying densities. After being passed through an effluent treatment system, the process water can be discharged into the sewage network.

The actual fractions are the gas, the light pyrolysis oil and the heavy pyrolysis oil. These oils are comparable to gasolene-type liquids and heavy fuel oil.

A schematic of the pyrolysis process (general) appears in Figure C-2.

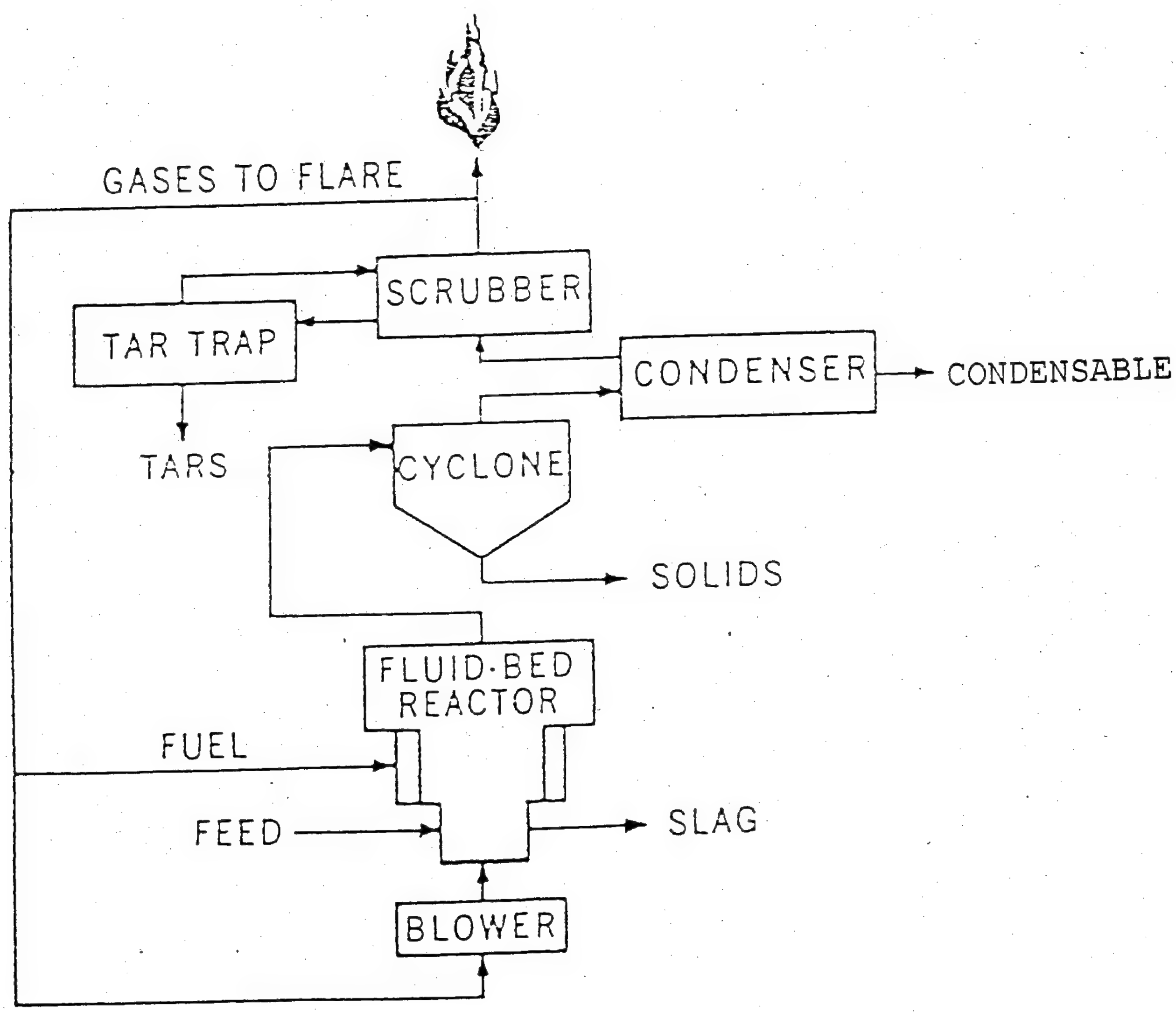


Figure C-2. Pyrolysis Process (General)

PROCESS DEVELOPMENT CONSIDERATIONS

In developing this process for conversion of plastics refuse to a usable energy source, the following items were considered.

1: Capital costs and operating expenses are to be <u>minimized</u>.

2: High pressure systems are to be avoided. (Atmospheric is desirable).

3: The use of pure oxygen and steam as raw materials is not to be considered.

4: The number of skilled operating laborers is to be <u>minimal</u>.

5: The process is to be flexible in size so as to accomodate the plastics refuse output of the particular area that the facility serves.

6: The process need not generate the equivalent of natural gas to be considered successful. The gas generated must be of sufficiently high value to be compressed and transported to a limited distance economically.

7: Very rapid heat transfer to each plastics waste particle to be pyrolyzed with isothermal operation is desirable.

8: High temperature heating capabilities should exist.

PYROLYSIS USING FLUIDIZED SAND & CHAR RECYCLES

This fluidized bed system uses the heat given off by the combustion of pyrolysis char to supply the energy needed in the plastics waste pyrolysis reaction. The oxygen required for combustion is supplied by compressed air, and in order to prevent the nitrogen in the air from diluting the pyrolysis gas, the two reactions are carried out in separate reaction vessels

Each vessel contains equal depths of fluidized sand particles, and the sand can be induced to flow from one vessel to another. The sand flow from the combustion reactor at 1750 deg. F to the pyrolysis reactor at 1350 deg. F supplies the heat necessary for the chemical decomposition of plastics waste to occur. The solid feed to the pyrolysis unit is plastics waste, while that to the combustion unit is the solid char formed from the plastics waste pyrolysis reaction. The high heat transfer rate and isothermal conditions of the fluidized bed are very desirable for fuel gas production. A simple schematic of this process is shown in Figure C-3.

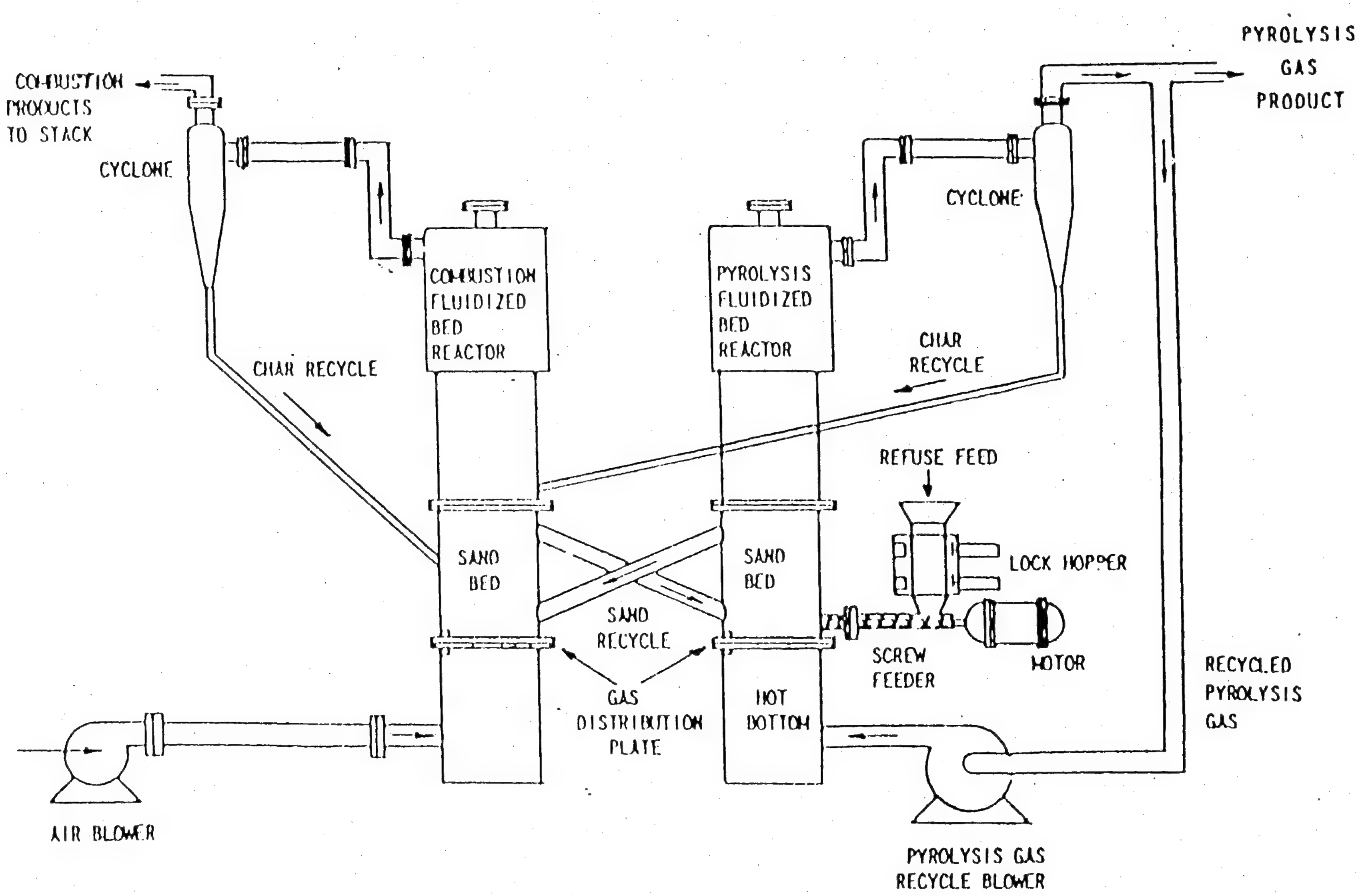


Figure C-3. Pyrolysis Process Using Fluidized Sand and Char Recycles

The waste feed stream bears some mention. The system consists of a waste storage pit from where the waste is removed as needed and fed to a conveyor belt by a mechanical lift. The waste is passed to a sophisticated waste shredder where it is reduced in size. A PALLMANN heavy duty granulator (Series 600, 800 or 1260) is suitable for this purpose. The waste is passed through an air classifier where 90% of the metal, glass and heavy objects are removed. The classified waste is then fed by conveyor to a lock hopper-screw feeder apparatus where the waste is fed directly into the fluidized bed.

270 LBS. PER DAY FACILITY

Assumptions

1: A ship having 300 persons is considered.

2: Plastics waste per person per day is assumed to be 0.9 lb.

3: Operating period is assumed to be 12 hours per day.

Plastic waste estimation

Total plastics waste per day will be (300 x 0.9 lb.), i.e. 270 lbs.

The equipment will be required to handle plastics waste of 270 lbs. per 12 hours, i.e. 22.5 lbs. per hour.

FACILITY DESCRIPTION

The following is a short description of the equipment used to process 270 lbs. per day of plastics waste. The schematic of the entire plastics waste pyrolysis system is shown in Figure C-4.

The combustion unit is a fluidized bed 1 inch in diameter and 6 inches high. The sand bed height is 1 inch and the harmonic mean particle diameter of sand is 0.025 inch. The combustor will be fed the recycled char produced in the gasifier unit and will operate at 1750 deg. F. The bed velocity will be three times the minimum fluidization velocity. The off-gas from the combustor will pass through two cyclones to effect gas clean up. The first cyclone will remove large solid particles while the second will remove the smaller particles. The char removed from the cyclones will be returned to the combustor for fuel. The combustion products will then be passed through a heat exchanger to preheat the air entering the combustor.

The fluidized pyrolysis unit will be 2 inches in diameter and will have an overall height of 6 inches. The sand bed height and sand particle diameter will be the same as for the combustor. The pyrolysis unit will operate at 1350 deg. F and will gasify 22.5 lbs. per hour (or 270 lbs. per day) of plastics waste. The gas to fluidize the pyrolysis unit will be supplied by recycling the pyrolysis gas. One-third of the gas produced will be recycled and the bed will operate at three times the minimum fluidization velocity. The pyrolysis gas stream will pass into a cyclone to remove the product of activated carbon char produced in the pyrolysis reaction. This char is fed to the combustion unit to supply the heat necessary to keep the fluidized sand temperature at 1750 deg. F. The energy required to maintain the pyrolysis unit at 1350 deg. F is obtained from the sand circulating from the combustion unit at 1750 deg. F.

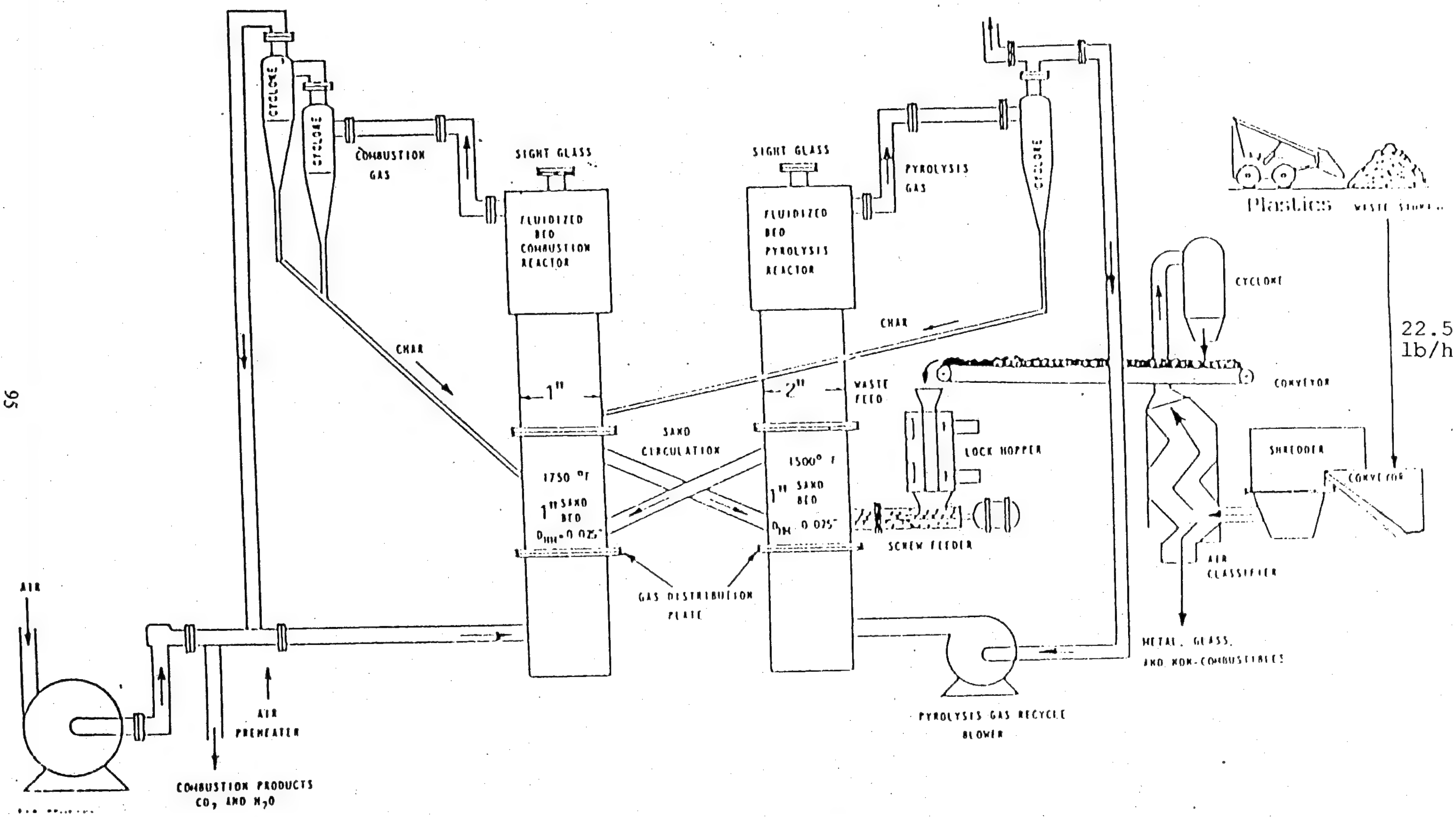


Figure C-4. Overall Schematic of 22.5 lb/hour Plastics Waste Pyrolysis Facility

UTILIZATION OF PYROLYSIS GAS

The pyrolysis gas has many direct applications. This gas can be used for heating and cooking. Other direct uses of this gas are for saline water conversion and steam production. Also the gas could be burnt in a jet engine type turbine for power generation.

The activated char produced by pyrolysis is also a valuable product. This char can be used directly as a solid fuel to perform some of the tasks of the pyrolysis gas mentioned above. The char can be used for general purification and reclaimation of liquid and gas streams. In particular, the char could be used to purify sewage sludge to obtain pure water and then the solids could be used as the energy source for the fluidized bed combustion unit. The activated char could be used to absorb metallic ions. The char could also be used as the fuel for the fluidized bed combustion unit and could be circulated with the sand. These processes are shown schematically in Figure C-5.

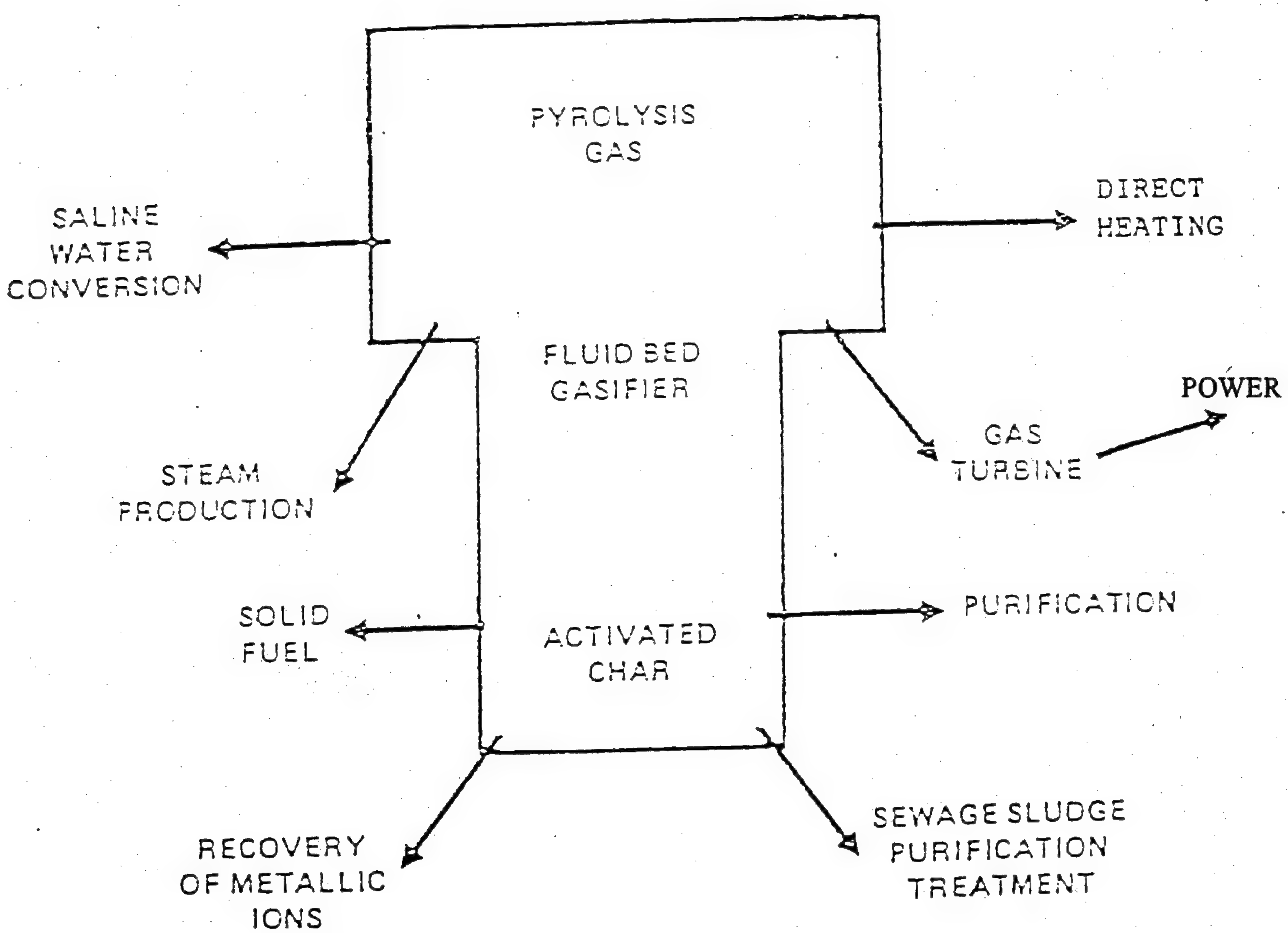


Figure C-5. Possible Uses of Gas and Char Products from Pyrolysis of Plastics Waste

REFERENCES

1: Leidner, J., "Plastic Waste- Recovery of Economic Value", Ed. Marcel Dekker, New York (1981).

2: Alter, H., "Encyclopedia of Chemical Technology", Vol. 19, Ed. Wiley, New York (1982).

3: Jackson, F., "Energy from Solid Waste", Noyes Data Corporation, New Jersey.

4: Hawkins, W. L., "Conservation & Recycling", 10, 1, 15-19 (1987).

5: Curlee, R., "Waste Age", pp 55-60, July 1987.

6: Magee, R. S., Proceedings Technology Exchange Program: "Plastics Recycling as a Future Business Opportunity", Washington D.C., 15-36 (1988).

7: Kaminsky, W., "Journal of Analytical & Applied Pyrolysis", 8, 439-448 (1985).

8: Davidson, J. F., "Fluidization", Academic Press (1985).

9: Levenspiel, O., "Chemical Reaction Engineering", Wiley (1983).

10: Botterill, J.S.M., "Fluid-bed Heat Transfer", Academic Press (1985).

APPENDIX D

Shipboard PRIME Survey
and
Summary of Results

DEPARTMENT OF THE ARMY
U.S. ARMY TROOP SUPPORT COMMAND
NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MA
01760-5018

REPLY TO ATTENTION OF
STRNC-WTS

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Plastic Removal in a Marine Environment (PRIME) Pre-Survey

1. The U.S. Army Natick Research, Development and Engineering Center (Natick), among other activities, has responsibility for the Department of Defense Food Research, Development, Testing and Engineering Program. Under the auspices of that program, we have been involved, from the beginning, with the Navy Food Service Systems Office, in the PRIME program. In the initial stages it was agreed that Natick would work with the non-hardware aspects and focus on food and food service. The Naval Sea Systems Command is working on hardware items such as pulpers, compactors and a plastic waste processor.

2. In the beginning some items were easily identified for replacement, e.g., plastic trash bags, plastic cups and the like. Other items, like sugar, were identified that are available in a plastic or non-plastic container. Still others, like plastic gloves, could be discontinued. These were relatively easy.

3. Some innovations have also been tried, e.g., ethylene absorbers to maintain the quality of fresh fruits and vegetables while reducing their plastic wraps and a water soluble adhesive instead of shrink wrap to secure pallet loads.

4. Through subject survey we hope to accumulate information so that individual ideas and approaches may be centralized and thus shared. We also hope to identify areas of potential gains that have not yet been evaluated. It is called a pre-survey because, hopefully, enough information and direction will be uncovered to warrant us to develop more specific questions.

5. We feel strongly that the problems, and often the best solutions, are logically identified by the people who work with the problem day after day. To get that feedback is the purpose of this open ended survey. The questions are topic guides. Do feel free to comment on anything appropriate or call the project officer, Mr. Joseph Wall, at DSN 256-4508 or (508)651-4508.

6. Data will be consolidated for analysis and not identified with any ship or person. Your participation and the time expended in having the enclosed

STRNC-WTS
SUBJECT: Plastic Removal in a Marine Environment (PRIME) Pre-survey.

pre-survey completed and returned to us are most appreciated. — The Soldiers' Command

FOR THE COMMANDER:

Encl

PHILIP BRANDLER
Acting Director
Food Engineering Directorate

DISTRIBUTION:
Commanding Officer
USS Simon Lake (AS 33), ATTN: XO, FPO NY 09536-2590
USS Holland (AS 32), ATTN: XO, FPO MI 34079-2585
USS Forrestal (CV 59), ATTN: XO, FPO MI 34080-2730
USS America (CV 66), ATTN: XO, FPO NY 09531-2790
USS Carl Vinson (CVN 70), ATTN: XO, FPO SF 96629-2840
USS Abraham Lincoln (CVN 72), ATTN: XO, FPO NY 09580-2872
USS Richmond K. Turner (CG 20), ATTN: XO, FPO MI 34093-1144
USS William H. Standly (CG 32), ATTN: XO, FPO SF 96678-1155
USS Leyte Gulf (CG 55) ATTN: XO, FPO MI 34091-1175
USS Normandy (CG 60) ATTN: XO, FPO NY 09579-1180
USS Texas (CGN 39) ATTN: XO, FPO SF 96679-1166
USS Mississippi (CGN 40) ATTN: XO, FPO NY 09578-1167
USS Spruance (DD 936) ATTN: XO, FPO NY 09587-1201
USS O'Brien (DD 975) ATTN: XO, FPO SF 96674-1213
USS Barney (DDG 6) ATTN: XO, FPO NY 09565-1236
USS Mahan (DDG 42) ATTN: XO, FPO MI 34092-1260
USS Rathburne (FF 1057) ATTN: XO, FPO SF 96677-1417
USS Jesse L. Brown (FF 1089) ATTN: XO, FPO MI 34090-1449
USS Jack Williams (FFG 24) ATTN: XO, FPO MI 34093-1480
USS Kauffman (FFG 59) ATTN: XO, FPO NY 09569-1513
USS Hercules (PHM 2) ATTN: XO, FPO MI 34091-3409
USS Peleliu (LHA 5) ATTN: XO, FPO SF 96624-1620
USS Duluth (LPD 6) ATTN: XO, FPO SF 96663-1709
USS Guam (LPH 9) ATTN: XO, FPO NY 09563-1640
USS El Paso (LKA 117) ATTN: XO, FPO NY 09568-1704
USS Pensacola (LSD 38) ATTN: XO, FPO NY 09582-1726
USS Fort McHenry (LSD 43) ATTN: XO, FPO SF 96665-1731
USS Barnstable County (LSD 1197) ATTN: XO, FPO NY 09565-1818
USS Shasta (AE 33) ATTN: XO, FPO SF 96678-3009
USS Mars (AFS 1) ATTN: XO, FPO SF 96672-3030
USS Williamette (AO 180) ATTN: XO, FPO SF 96683-3021
USS Seattle (AOE 3) ATTN: XO, FPO NY 09587-3014

STRNC-WTS
SUBJECT: Plastic Removal in a Marine Environment (PRIME) Pre-survey.USS Von

USS Wabash (AOR 5) ATTN: XO, FPO SF 96683-3027
USS Sentry (MCM 3) ATTN: XO, FPO SF 96678-1923
USS Sierra (AD 18) ATTN: XO, FPO MI 34084-2505
USS Steuben (SSBN 632) ATTN: XO, FPO MI 34094-2042
USS Kamehameha (SSBN 642) ATTN: XO, FPO NY 09576-2036
USS Greenling (SSN 614) ATTN: XO, FPO NY 09570-2325
USS Queenfish (SSN651) ATTN: XO, FPO SF 96676-2337
USS City of Corpus Christi (SSN 705) ATTN: XO, FPO NY 09566-2385
USS Atlanta (SSN 712) ATTN: XO, FPO NY 09564-2392

CF:
U.S. Navy Rep, Joint Technical Staff
Natick Reading File

C, EPS, SPB, FTD, FED

C, SPB, FTD, FED

C, FTD, FED

PLASTICS REMOVAL IN A MARINE ENVIRONMENT (PRIME)
PRE-SURVEY FORM

JUNE, 1991

1. Typical crew size: Officers ____ Chiefs ____ Enlisted _____

2. Typical number of meals: Breakfast _____ Lunch _____ Supper _____ Mid _____

3. In regard to how the PRIME program is now going, what's your first thought? ______________

4. Do you feel it is difficult to cooperate with efforts to eliminate dumping of plastic at sea? What specifically is difficult?
   a. ______________
   b. ______________

5. How do you deal with these difficulties, or how do you suggest they be dealt with? ______________

6. Is there plastic being used that could be eliminated? If so, describe it. ______________

7. Which plastic waste items take up the most storage space? How is the plastic waste stored?

8. What are the plastic items that continue to be dumped? ______________

9. Much of the waste plastic has food residue that can result in bad odors. How do you deal with this situation? ______________

10. Efforts have been made to use bulk instead of individual condiment packets. Has this been successful and how do you think it works? ______________

11. Are there similar efforts that could be made that haven't been? ______________

12. On the mess deck, are the patrons aware of the plastic program? Do they positively cooperate? Any unique problems? Like what? ______________

13. Have you seen changes from plastic to nonplastic packaging? Describe. ____________________

14. Do you feel that enough effort is made to leave as much plastic as is possible on shore? Have you been encouraged to do this? ____________________

15. Present rules require food contaminated plastic to be held for 3 days and non-contaminated for 20 days. Is it reasonable? Does it work? ____________________

16. Does you ship participate in any port recycling programs such as aluminum, paper or plastic?

17. What types of training did you receive on PRIME? What additional training is needed?

18. If you use ethylene absorbers, do you find them useful? If not, why not?

19. Eventually, technology will provide a tool to make the task of dealing with waste plastic easier. However, in the meantime source reduction will remain an important aspect of the program. Reducing the volume helps both from reducing the workload onboard and in reducing that which will go to a landfill. So, finally, from "in the trenches" anything you'd like to add from your experiences will be appreciated. Use the reverse. THANKS!.

20. Please indicate how much you agree or disagree with each of the following statements: (Circle one number per statement)

	Strongly Disagree		Neither Agree Nor Disagree		Strongly Agree
a. The environmental problems caused by waste disposal have been exaggerated.	1	2	3	4	5
b. Dumping plastic waste overboard is a serious threat to the environment.	1	2	3	4	5
c. Waste products disintegrate more easily in a marine environment than they do on land.	1	2	3	4	5
d. Making waste disposal at sea less environmentally harmful should be a priority on board ship.	1	2	3	4	5
e. Recycling should be the primary method with which to solve environmental problems.	1	2	3	4	5
f. A biodegradable package eventually decomposes naturally in the environment.	1	2	3	4	5
g. Biodegradable materials decompose quickly.	1	2	3	4	5
h. Biodegradable products are basically the same as recyclable products.	1	2	3	4	5
i. Biodegradable products can be used again or processed into something else.	1	2	3	4	5
j. Paper products are less environmentally harmful than biodegradable plastics.	1	2	3	4	5
k. Biodegradable packages would protect food better than would regular packages.	1	2	3	4	5
l. Biodegradable packages are sturdier than regular packages.	1	2	3	4	5
m. Biodegradable plastic utensils would disintegrate if used in hot soup or coffee.	1	2	3	4	5
n. A biodegradable package will begin to disintegrate and contaminate the food inside the package.	1	2	3	4	5
o. Using biodegradable products on board ship will require sailors to do more waste separation.	1	2	3	4	5
p. When developing a new waste disposal program, one of the first considerations should be the amount of work it creates for sailors.	1	2	3	4	5
q. Environmentally safe packages should carry a government label approving their safety.	1	2	3	4	5
r. To make them easy to recognize, biodegradable packages should have a special seal.	1	2	3	4	5
s. A package is considered environmentally safe if it has on it a manufacturer's claim to that effect.	1	2	3	4	5

21. If biodegradable products were used on board Navy ships, how effective do you think each of the following methods would be for assuring sailors' compliance with any changes in procedure: (Circle one number per method)

	Very Ineffective		Neither Effective Nor Ineffective		Very Effective
a. Sailors given direct orders by a superior officer.	1	2	3	4	5
b. Posters hung on board ship that advertise the importance of the changes.	1	2	3	4	5
c. Rules and procedural changes posted on board ship.	1	2	3	4	5
d. A video shown on board ship every few months that advertises the changes and their importance.	1	2	3	4	5
e. Commercials on TV, radio, and in magazines that advertise the changes and their importance.	1	2	3	4	5
f. Brochures mailed directly to sailors that explain the changes and their importance.	1	2	3	4	5
g. Periodic visits from personnel from government health and safety offices who explain the changes and their importance.	1	2	3	4	5
h. Presentations by other sailors who have been trained in communicating any changes in procedure and their importance.	1	2	3	4	5
i. Giving rewards and recognition commendations to those crews and/or individuals who excel in their compliance with any changes.	1	2	3	4	5

Question 1 and 2 addressed the numbers assigned and the number of meals served.

3. IN REGARD TO HOW THE PRIME PROGRAM IS NOW GOING, WHAT'S YOUR FIRST THOUGHT ?

- a positive step to protect the environment, objectives are well understood, feedback is vital, needs proper attention at every level of Command

- change contract standards for FFV for non-plastic containers. Change soda packaging to non-plastic

- lots of rules passed without tools to implement, trash compactor in particular, technology would increase emphasis and reduce effort, another program implemented without much thought, no standardization.

- does not affect submarines

- the program is a significant burden on the fleet, we require great support from manufacturers and military purchasing agents to force change from plastic packaging

- placards/posters and formal crew education required for plastic hazard awareness.

4. DO YOU THINK IT IS DIFFICULT TO COOPERATE WITH EFFORTS TO ELIMINATE DUMPING OF PLASTIC AT SEA? WHAT SPECIFICALLY IS DIFFICULT?

- yes, certain areas are more difficult such as food service, food contaminated plastic still a problem, large amounts of plastic generated in a short period due to packaging, constraints imposed by operational requirements; separation, storage, and disposition

- inadequate storage space, storage (size, location, design) not identified, lack of standardized containers (bags, compactors) and or fleetwide identification of items

- labor increase is not supported with manning, trash compactor requires a full-time person

- training work centers to separate trash, continuing education due to personnel rotating and tendency to forget during long inport periods, on environmental impact, training must be continuous particularly on ships with transitory personnel.

- attention from shore establishment support seems to be lagging behind what is expected from the ships, eliminate the source, i.e., bubble wrap, plastic protection for spare parts and provisions

- storage of plastic waste on submarines, submarine disposal remains the same

5. HOW DO YOU DEAL WITH THESE DIFFICULTIES, OR HOW DO YOU SUGGEST THEY BE DEALT WITH?

- lack of storage mandates use of a compactor, trash cans to accommodate compacted trash should also be provided, provide ships with equipment, delay implementation until all issues have been resolved and equipment installed, improved garbage grinders.

- document additional workload for manning

- have a salvaged wooden crate on fantail, it's an eyesore

- lack of hardware, equipment

- publish notes in plan of the day to remind crew

- separate contaminated plastic then rinse/wash to eliminate odors.

- more support from the shore establishment, eliminate as much plastic as possible, requires top management attention, contractors must be educated about purchases without plastic associated packaging

- Melt and pack plastic on board to be stored in blocks

- we need more handouts, movies and advertisements to get everyone actively involved through education.

6. IS THERE PLASTIC BEING USED THAT COULD BE ELIMINATED? IF SO, DESCRIBE IT

- packaging peanuts and other styrofoam could be changed to shredded paper or other biodegradable packaging, plastic wrap used to collate boxes on a pallet; a major plastic use on AFS ships, bubble wrap, popcorn, soda syrup in plastic bottles, cereal packages, detergent containers, soda six pack rings, shrink wrap, snack food wrappers, plastic wrap on spare parts, retail sales, safety seals, meat wrapping in wax paper instead of plastic, milk containers

7. WHICH PLASTIC WASTE ITEMS TAKE UP THE MOST STORAGE? HOW IS THE PLASTIC WASTE STORED?

- styrofoam in all forms, plastic wrapped cardboard boxes used in cargo group 89, plastic trash bags, plastic waste from the galley, milk containers and detergent containers, bubble wrap, prepackaged snack items, plastic knives, forks and spoons, garbage bags that hold contaminants

- compact and hold until get to port, stored in former equipment space and little used heads, at sea plastic is maintained in trash cans on the upper level of the ship, stored anywhere we can find, there is inadequate space in a submarine no matter how it is treated, in tri-walls on the fantail and in plastic bags, or retained at the workstation

8. WHAT ARE THE PLASTIC ITEMS THAT CONTINUE TO BE DUMPED?

- small items that escape our inspection and are part of the wet garbage, occasionally are forced to dump galley trash with contaminated trash, milk bags, meat wrappings and other food contaminated plastic that becomes a sanitation problem when held for a period, styrofoam packaging, plastic bags being used for wet garbage, any food contaminated plastic

- no plastic being dumped, transferred plastic to oiler for shore disposal, this should be standard Navy/DoD policy for resupply ships to provide until technology is installed to deal with the problem, all plastic is maintained on board until ship returns to port.

9. MUCH OF THE WASTE PLASTIC HAS FOOD RESIDUE THAT CAN RESULT IN BAD ODORS. HOW DO YOU DEAL WITH THIS SITUATION?

- milk and dairy products most especially, extremely difficult situation to deal with. Education of food service personnel to double and even triple bag possible odorous waste and management attention deal effectively with the problem.

- compacted for negative buoyancy, kept sealed in waxed boxes or plastic bags to keep odors in and insects out, the ugly box is on the weather deck so fumes are naturally vented, actually wash it before storing it, utilize double plastic bags, stored outside on the weather deck, bagged and placed on station amidships outdoors, there is not much you can do but throw it overboard, we insure food grinders are repaired to minimize wet garbage which necessitates plastic bags.

- not stored on a submarine

- no real solutions except to clean up after dumping inport

- continue to dump all food residue waste

10. EFFORTS HAVE BEEN MADE TO USE BULK INSTEAD OF INDIVIDUAL CONDIMENT PACKETS. HAS THIS BEEN SUCCESSFUL AND HOW DO YOU THINK IT WORKS?

- very successful and should continue, don't use individual condiments, this helps to reduce a significant amount of trash, a major plastic waste item has been reduced, bulk items are easier to handle, inventory and to separate; only exception are sugar packets, prior to underway condiments packets are pulled from galley spaces

- still required for boat meals, flight meals and ideal for steel beach picnics

in normal_mess bulk is used

11. ARE THERE SIMILAR EFFORTS THAT COULD BE MADE THAT HAVEN'T BEEN?

- a mechanical separator, add garbage, lots of sea water and a mulcher centrifuge to separate plastic and discharge garbage to sea.

- many foods come individually packed, use more bulk containers

- plastic packaging reduction, candy sold from ships store, find a suitable substitute for the milk bags

- use of biodegradable packaging, use of garbage compactors, use of biodegradable packaging in parcel post delivery.

12. ON THE MESS DECK, ARE THE PATRONS AWARE OF THE PLASTIC PROGRAM? DO THEY POSITIVELY COOPERATE? ANY UNIQUE PROBLEMS? LIKE WHAT?

- Positively no, even with signs and a full time person; since not learned at home the training is constant.

- yes, well advertised, and we devote one "sheriff"; yes, mess deck is set up with three sets of trash containers, plastic only, papers and garbage.

- they are aware, most cooperate but it doesn't take very many to mess up the job. no unique problems; are aware but need to be reminded constantly; 50/50, Training is helping but needs to continue; the key is making it easy to comply, we had little plastic to deal with on the mess deck; most people have only a vague knowledge but will cooperate if provided with large easily identifiable containers to separate, education is the key.

13. HAVE YOU SEEN CHANGES FROM PLASTIC TO NON-PLASTIC PACKAGING? DESCRIBE.

- seven of the replies were negative.
- others cited bubble wrap being eliminated, the use of ethylene absorbers with fresh fruits and vegetables, major bottling companies providing soda without the plastic rings although they noted a slight increase in cost, most shrink wrap noting that most stock shipping points are using considerably less plastic wrap.

14. DO YOU FEEL THAT ENOUGH EFFORT IS MADE TO LEAVE AS MUCH PLASTIC AS IS POSSIBLE ON SHORE? HAVE YOU BEEN ENCOURAGED TO DO THIS?

- eight responses were positive, items noted were bread racks, cups, aprons, plastic gloves; more effort could be made however, the trade-off for food has to be resolved in the packaging of the item

- three responded negatively, an effort is made but a lot more could be eliminated, a significant amount of plastic could have been eliminated before it was shipped to us, we try to leave plastic on shore however much is required for the safety of the packaging, not enough effort is made

- to the maximum possible, Command policy is to leave plastic on shore, monitoring the purchase of supplies avoiding items made of plastic.

15. PRESENT RULES REQUIRE FOOD CONTAMINATED PLASTIC TO BE HELD FOR THREE DAYS AND NON-CONTAMINATED FOR 20 DAYS. IS IT REASONABLE.

- nine responses were positive, only effective if strictly enforced, rinsing and compacting seem to help, it works but it is not easy, a major effort by the ship, a reasonable time but there is still a serious problem with the smell of the waste, a sanitation/fire hazard

- one response was negative, storage continues to be the major problem in that it is manpower intensive to comply and enforce, long lead times jeopardize sanitation requirements near food areas

16. DOES YOUR SHIP PARTICIPATE IN ANY PORT RECYCLING PROGRAM SUCH AS ALUMINUM, PAPER OR PLASTIC?

- five responses were positive, all aluminum except steel/metal at one location.

- seven responses were negative, all because there is no recycling system available to them.

17. WHAT TYPES OF TRAINING DID YOU RECEIVE ON PRIME? WHAT ADDITIONAL TRAINING IS NEEDED?

- eight responses were negative, training is not the problem, we need the tools

- of the affirmative, during schools before arrival on ship, boot camp, SWOS, divisional training, department head division officer training, written shipboard instructions, video tapes, hazmat training

18. IF YOU USE ETHYLENE ABSORBERS DO YOU FIND THEM USEFUL? IF NOT, WHY NOT?

- eight responses were negative, not available, not familiar with these, what are they?

- four were positive, they are super but we are still learning how best to use them, useful but not readily available in the supply system, significantly add to the shelf life of fruits and vegetables,

19. Question 19 asked for any comments they would like to make based on their experience working with the problem. Significant comments were:

- need more shore\ ship, supplier\ NSC\ ship coordination, i.e., change the military specs. Spare parts, test equipment are received in bubble wrap, mylar and styrofoam bubbles. What's wrong with shredded paper?

- Trash compactors can get us over the hump. Guidance is needed on which compactors are best suited for shipboard use.

- Further training and elimination of plastic is needed. Once recycling and not dumping at sea is routine to everyone this program will become second nature to all hands.

- Need to focus on transferring as much workload as possible off the ships. Focus also needs to be on making it easy to comply with and support the program than it is to do it improperly. Directing use of cumbersome program will be substantially ineffective.

- The plastics at sea video series are extremely beneficial in crew awareness training. However, update is required to be more effective. The best answer to the problem of managing plastics at sea is the installation of trash compactors and better designed garbage disposals.

- Navy contracts in food packaging can be revised to prescribe the use of plastics. Current plastic disposal can and should be dealt with in a melting machine that sanitizes. If we're serious about this program then have a fleet wide contract with the best system available to handle plastics - just like we have for dish detergent systems.

- The use of special trash holding areas, specific only for trash, convenient for dumping or removal ashore, would reduce the volume and workload. Trash compactors and reliable garbage grinders need to be maintained on all ships.

DISTRIBUTION LIST

One copy of this report, unless otherwise indicated, is distributed to each address below.

Naval Surface Warfare Center - DET Annapolis 25
Carder Rock Division
ATTN: Code 634 (Craig S. Alig)
Annapolis, MD 21402-5067

Chief of Naval Operations
ATTN: Code N452 (Larry Koss)
Crystal City, Jefferson Davis Highway
Arlington, VA 22241-5360

Commander in Chief, Atlantic Fleet
ATTN: Code 412C (CDR Phil Pfeil)
Norfolk, VA 23511

Commander in Chief, Pacific Fleet
ATTN: Code 4121 (Franklin Veninger)
Pearl Harbor, HI 96860-7000

Commander Naval Air Force, U.S. Pacific Fleet
ATTN: Code 454D (Gerry Parks)
Naval Air Station, N. Island
San Diego, CA 92135-5100

Commander, Naval Air Force, U.S. Atlantic Fleet
ATTN: ATTN: Code 421 (LCDR Kevin Kearney)
Norfolk, VA 23511-5188

Naval Supply Systems Command
ATTN: Code SUP4522 (Jill Ballard)
Crystal City, Jefferson Davis Highway
Arlington, VA 22241-5360

Commander, Naval Surface Force, Pacific Fleet
ATTN: Code N416 (Doug Rose)
Naval Amphibious Base, Coronado
San Diego, CA 92155-5035

Commander, Naval Surface Force, Atlantic Fleet
ATTN: Code N711 (LT Paul Park)
Norfolk, VA 23511-6292

Commander, Naval Sea Systems Command
ATTN: Code 03V (Tom Scarano)
Arlington, VA 22241

Commandant
U.S. Army Quartermaster Center and School
Ft. Lee, VA 23801

Commanding Officer
Navy Food Service Systems Office
Bldg 166, Washington Navy Yard
Washington, DC 20374-1662

HQ AFESC/DEHF
Tyndall Air Force Base, FL 32403

R&D Associates for Military Food and
Packaging Systems
103 Biltmore Drive, Suite 106
San Antonio, TX 78213

AFFTC Technical Library
412 TW/TSTL
307 E. Popson Ave, Ste. 106
Edwards Air Force Base, CA
93524-6630

DISTRIBUTION LIST *(Continued)*

Commander, U.S. Army Natick RD&E Center
Kansas Street
Attn: SATNC-Z
SATNC-T
SATNC-ZSN
SATNC-A
SATNC-MIL (Technical Library 7 copies, including 2 copies:
Defense Technical Information Center, Alexandria VA)
SATNC-TR
SATNC-TF
SATNC-TI
SATNC-TM
SATNC-TN
SATNC-W
SATNC-WE (30 copies)
SATNC--Y
Natick, MA 01760